# Appendix D Investigation and Analysis Report

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# Dam Existing Condition and Concept Design Hydrology and Hydraulics Investigation and Analysis Report

Escondido Creek Floodwater Retarding Structure No. 12 Rehabilitation Project

Karnes County, Texas

U.S. Department of Agriculture - Natural Resources Conservation Service

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Delivering a better world

Prepared for:

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# Table of Contents

## Figures



## Tables

## Exhibits

# 1. Introduction

Escondido Creek FRS No. 12 is a Natural Resources Conservation Service (NRCS) designed dam built in 1974. The dam is located southwest of Karnes County within the Escondido Creek watershed. The purpose of this report is to capture the existing state of the dam and appurtenances, to document the best available data and methodology used in the Hydrologic and Hydraulic (H&H) analysis of the existing condition and the preferred alternative, and to present the results.

Escondido Creek FPS No. 12 requires upgrade based on the following concerns:

- The dam does not meet the current safety and performance criteria for high hazard dam.
- Downstream risk from a catastrophic breach. Approximately 88 habitable structures and 22 roads are within the sunny-day breach boundary.
- Extend the reservoir useful life by at least 50 years, preferably by 100 years.

# 2. Description of Existing Dam

The following sections reporting the existing conditions of FRS No. 12 is a compilation of the Dam Assessment Report (AECOM, 2014), Dam Safety Inspection Reports (TCEQ 2013, SARA 2017, and SARA 2021), and the FRS No. 12 As-built plans (USDA SCS, 1974) in addition to observations made during site visits associated with this Supplemental Watershed Plan (SWP) effort. All elevations referenced in this report are given in feet, North American Vertical Datum (NAVD 88), unless otherwise noted.

## 2.1 Current Condition of the Dam

FRS No. 12 is located in southwest Karnes County, Texas approximately 4.0 miles south of Karnes City, Texas. The FRS is located on Bucker Creek, a tributary of Escondido Creek, and a tributary of San Antonio River. FRS No. 12 is a typical NRCS earthen embankment dam with storage allocated for sediment accumulation and flood control. The 2021 Dam Safety Inspection Report (SARA, 2021) classifies the dam as Not Unsafe and Good condition with Adequate operation and maintenance. Observations from the Dam Safety Inspection Report (SARA, 2021) are included in **Section 2.5** through **Section 2.7**. The following items were noted as summary/recommendations in the inspection report.

- No immediate safety concerns were observed.
- The dam is being maintain as expected.
- Minor repairs are needed to fill animal burrows and hog damage on the embankment.
- Surface cracking on the downstream slope need to be investigated to see if they pose a structural threat.
- Drought conditions are causing vegetation to deteriorate on sides with southern sun exposure.

- There is home construction upstream of the dam within the reservoir area.

The Sponsor is aware of the items noted above. These observations are not impacting the performance of the dam and are not the cause of the needed dam rehabilitation.

## 2.2 Potential Dam Safety Deficiencies

FRS No. 12 was constructed in 1974 to be a single-purpose, low hazard potential dam. Because there is a potential risk for loss of life downstream due to residential development and several roads should the dam breach, the structure is now classified as a high hazard potential dam. Currently the dam does not have the auxiliary spillway capacity to safely pass the Freeboard Hydrograph (FBH) for a high hazard potential dam without overtopping the embankment. In addition, the dam does not meet the 10-day drawdown requirement and engages the auxiliary spillway during the Principal Spillway Hydrograph (PSH) event.

## 2.3 Status of Operations and Maintenance

Dam operation and maintenance (O&M) of FRS No. 12 is performed by the San Antonio River Authority (the River Authority) via a contracted agreement between the Escondido Watershed District and the River Authority with 50% cost share. The last three dam safety inspections were completed by the River Authority on January 23, 2017, and March 10, 2021 and by Texas Commission on Environmental Quality (TCEQ) on July 23, 2013. The latest O&M inspection was conducted December 2020.

Maintenance activities generally consist of repairing surface erosion, clearing brush from the auxiliary spillways and embankment slopes, mowing grass, and access road maintenance. Maintenance activities, such as mowing and tree removal, access road repair, and repair of animal burrows and hog damage, are reported to be periodically performed. Based on the site visit on January 30, 2024, O&M on FRS No. 12 is considered adequate.

## 2.4 As-Built Dam Specifications

FRS No. 12 was designed and constructed in 1974 to be a single-purpose, low hazard potential dam. The embankment is a single zone, compacted earthfill dam and is noted to have an impervious core. A cutoff trench with 1:1 side slope that has a minimum bottom width of 12 feet was constructed at the centerline of the dam. The dam is approximately 34 feet tall and 2,298eet long. Both the upstream and downstream slopes of the embankment have a slope of approximately 2.5:1 (horizontal: vertical). The top width of the structure is approximately 14 feet. The land upstream of FRS No. 12 is predominantly private ownership. **Table 2.1** summarizes the as-built and existing structural data for FRS No. 12.

**Table 2.1. As-Built and Existing Structural Data for FRS No. 12**

| Item | FRS No. 12 | |
|---|---|---|
| | As-Built[a] | Existing[b] |
| Latitude / Longitude | 28.830737 º / -97.923172 º | |
| Site Number | TX04315 | |
| Year Completed | 1974 | |
| Purpose | Flood Control | |
| Drainage Area (mi$^2$) | 6.1 | 6.06 |
| Dam Height (ft) | 34 | |

| Item | FRS No. 12 | |
|---|---|---|
| | As-Built[a] | Existing[b] |
| Dam Type | Homogenous Earthfill | |
| Dam Volume (yds$^3$) | 168,192 | |
| Dam Crest Length (ft) | 2,298 | 2,298 |
| Total Capacity (ac-ft)[c] | | |
| Sediment Submerged (ac-ft) | 364 | 386.9 |
| Sediment Aerated (ac-ft)[d] | 59 | 51.7 |
| Floodwater Retarding (ac-ft) | 1421 | 1472 |
| Surface Area (ac) | | |
| Low Stage Principal Spillway (ac) | 55 | 51.5 |
| High Stage Principal Spillway (ac) | 79 | 77.9 |
| Flood Pool (ac)[e] | 201.6 | 199.2 |
| Principal Spillway | | |
| Type | Drop inlet | |
| Riser Height (ft) | 9 | |
| Conduit Size (in) | 42 | |
| Low Level Port Elevation (ft) | 322.63 | 322.63 |
| Riser Crest Elevation (ft) | 325.13 | 325.13 |
| Capacity at Aux Crest (cfs) | 192.6 | 190.3 |
| Energy Dissipater | Plunge Pool | Plunge Pool |
| Auxiliary Spillway | | |
| Type | Earthen channel with protective vegetative cover | |
| Auxiliary Spillway Width (ft) | 300 | |
| Normal Pool (Low Stage) Elevation (ft) | 322.63 | 322.63 |
| Principal Spillway Crest Elevation (ft) | 325.13 | 325.13 |
| Flood Pool Elevation (ft) | 336.13 | 335.68 |
| Top of Dam Elevation (ft) | 342.23 | 342.23 |
| Datum[a,b] | NAVD88 | |

a. As-built elevations are referenced to NGVD29 and were updated to NAVD88 datum Geoid 12B for this plan using conversion factor of +0.13 feet.
b. No site topographic survey was performed as part of this plan; all analysis was based upon Hurricane Light Detection and Ranging (LiDAR) 2019 data.
c. A sediment survey was performed as part of this plan; elevation-storage analysis was based upon the combination of sediment survey performed in January 2024 and Hurricane LiDAR 2019 data.
d. Aerated sediment storage above the principal spillway crest is included in the as-builts.
e. The flood pool is defined at the elevation of the auxiliary spillway crest (at elevation 336.13 feet for as-built condition)

## 2.5 Principal Spillway

The principal spillway inlet structure is a drop inlet (42 inches x 126 inches) with an anti-vortex baffle and crest of 325.13 feet. There are four low level ports (two 12 inches x 36 inches on each side) at elevation 322.63 feet. The conduit is 192-feet long of 42-inch-diameter, concrete-lined steel cylinder pipe with 5 anti-seep collars.

According to the 2021 inspection report from the River Authority, the principal spillway appeared to be functioning properly with no deficiencies noted with the single exception of undesirable vegetation near principal spillway conduit support cradle. Photographs of the existing principal spillway system, taken during a site visit on January 30th, 2024, are provided in **Figure 2.1.**

Inlet structure looking south

Inlet structure looking southwest

Inlet structure

Conduit outlet and plunge pool

**Figure 2.1 FRS No. 12 Principal Spillway Inlet and Outlet**

FRS No. 12 principal spillway conduit inspection was performed on November 21, 2024 by the River Authority. The inspection included video documentation to assess the existing condition of the principal spillway. The riser and conduit are in an acceptable condition to remain in place for rehabilitation design. The key findings from the survey are summarized as follows:

- Area of spalled concrete (82 feet from downstream end); monitor periodically.
- Joints generally look good.

- Hairline cracking and minor chipping near one joint (49 feet from downstream end) but that could have happened during installation. Cracks do not appear to be a concern.
- At inlet, exposed steel at conduit/riser interface of left side, looking downstream. This is a minor issue that can be cleaned at patched.
- Staining at construction joint on the interior, upstream face of the inlet wall may be a sign of leakage through the joint when the water is up against the inlet. Cannot be confirmed as a leak without a site visit or observing leaking through the joint.
- Overall, pipe is in very good condition.

## 2.6 Auxiliary Spillway

The auxiliary spillway is a 300-foot-wide, grass-lined channel with 3H:1V side slopes. The as-built drawings show the auxiliary spillway as having a 10% slope grassed inlet section up to 100-foot-long control section at elevation 336.13 feet and exit section with slopes ranging from 2.6% to 1.1% extending for approximately 510 feet before transitioning back to the original ground. Per correspondence with the River Authority, there is no record of the auxiliary spillway flowing since dam construction.

According to the 2021 inspection report there were no deficiencies in the auxiliary spillway. The vegetation in auxiliary spillway was recovering nicely from the drought that was noted in the previous inspection. Although sparse vegetation in spots was observed, the maintenance crew was working to encourage more vegetation growth. Auxiliary spillway photos are provided in **Figure 2.2**.

Auxiliary spillway

Auxiliary spillway channel downstream of control section

**Figure 2.2 FRS No. 12 Auxiliary Spillway Condition**

## 2.7 Embankment

According to the 2021 inspection report by the River Authority, the embankment was in overall good condition and had improved significantly from the previous inspection; however, there was still a concerning amount of sparse vegetation and evidence of wind erosion where bare soil was exposed. There were animal burrows on occasion, a continual issue for this region, as well as a hog damage. The River Authority repairs the burrows after discovery. Dam embankment photos are provided in **Figure 2.3**.

Upstream embankment

Downstream embankment

Downstream embankment showing burrows

Top of embankment

**Figure 2.3 FRS No. 12 Embankment Condition**

## 2.8 Topographic Data

No Topographic survey was performed in support of plan development. A topographical survey may be performed as part of a future final design phase. Light detection and ranging (LiDAR) data combined with as-built elevations were the basis for critical elevations and the design of rehabilitative measures. The LiDAR data source that provided coverage for the analysis include:

- United States Geological Survey (USGS) Hurricane LiDAR 70-cm resolution LiDAR for Karnes County. Data was collected and processed by Fugro between January 4, 2019, through February 20, 2019 and published in June 2020.

The LiDAR coverage with respect to the location of FRS No. 12, the contributing watershed, and the area used for evaluation is shown in **Exhibit D-1.** The Mosaic tool in ArcGIS was used to combine the initial Digital Elevation Model (DEM) tiles into a single DEM at 1-meter resolution. The USGS Hurricane Lidar datasets were referenced to GEOID12B. The DEM was re-projected from UTM to Texas State Plane South Central coordinate system and elevations were converted from meters to feet. The re-projected DEM was supplemented with bathymetric data which was collected during the sediment survey. The merged DEM was then used to verify as-built elevations (adjusted from NGVD29 to NAVD88) and to develop 1-foot interval contours for use in the existing condition analysis and design of rehabilitative measures. The combined DEM was also used to develop the elevation-storage relationship presented in **Section 2.9**.

A bathymetric and sediment survey was performed by Aqua Strategies, Inc. (ASI) on January 30, 2024, to obtain sediment accumulation since construction and to estimate sediment accumulation rate (ASI, 2024). Bathymetric and sediment data were collected using a vessel-mounted Specialty Devices Inc. (SDI) multi-frequency (200 kHz, 50 kHz, and g12 kHz) BSS+ sub-bottom profiling echosounder integrated with GPS equipment (ASI, 2024). The ASI data were converted from 2-foot resolution raster to 1-meter raster to match the LiDAR resolution. The DEM and the ASI bathymetry raster were then merged, with the bathymetry replacing the underlying DEM data. The result is an elevation model that includes bare earth and the current reservoir bottom surface. The combined DEM was also used to develop the elevation-storage relationship presented in **Table 2.2**.

## 2.9 Sediment and Reservoir Storage

FRS No. 12 was designed for a service life of 50 years with a sediment storage volume of 198 acre-feet below the low-level ports in the principal spillway riser**.** The four ports set the normal pool surface area at 55 acres. The submerged sediment storage at the principal spillway crest elevation of 325.13 feet is 364.0 ac-feet. The total sediment storage including the aerated sediment was set at 0.64 feet above the elevation of the principal spillway crest, with 423 acre-feet of storage at elevation 325.77 feet (NAVD 88 adjusted). The surface area at the principal spillway riser crest was planned at 79 acres. The elevation-storage relationships from both as-built data and estimated from LiDAR (2020) data is provided in **Table 2.2**.

According to *Volumetric and Sediment Survey of Escondido Creek WS SCS Site 12, Karnes County, Texas* (ASI, 2024) 20.5 acre-feet of sediment has accumulated since as-built plans completed in 1974 (49 years). The sediment accumulation rate is therefore approximately 0.42 acre-feet per year. Therefore, 100 years of future submerged sediment storage would be 41.8 acre-feet. To account for an additional 5 years between the 2024 bathymetric data collection and the estimated rehabilitation construction completion (2024 to 2029), the total minimum submerged sediment storage volume needed is 44 acre-feet.

The accumulated maximum sediment of 20.5 acre-feet at the time of bathymetric survey plus the projected 44 acre-feet is only 64.43 acre-feet, less than the 364 acre-feet originally planned at the principal spillway crest elevation. Using the 2019 LiDAR merged with ASI sediment survey storage indicates that there is approximately 386.9 acre-feet available below the existing principal spillway crest elevation of 325.13 feet, which also exceeds the projected storage required of 44 acre-feet for future submerged sediment. Either estimate used (i.e., as-built storage or sediment survey storage) indicates there is 100-years available future submerged sediment storage at Escondido FRS No. 12 below the elevation of the existing principal spillway crest.

Based on this evaluation, the existing principal spillway crest was maintained at 325.13 feet and the proposed secondary principal spillway crest for all high hazard options evaluated was set at 325.1 feet for FRS No. 12, providing 384.1 acre-feet of available sediment storage. The crest cannot be lowered any further due to the hydraulic proportioning needed for the principal spillway riser.

Aerated sediment volume was included above the principal spillway crest in the as-builts. For concept design modeling, aerated sediment storage volume above the principal spillway crest was included at 14% of the combined required sediment storage (44 acre-feet submerged plus 7.1 acre-feet aerated). This 7.1 acre-feet of aerated sediment, rounded to 8 acre-feet of aerated sediment, sets the starting water surface elevation for the design runs at 325.23 feet.

**Table 2.2. As-Built and Existing Storage for FRS No. 12**

| Notes | Elevation (ft NGVD 29) | Elevation (ft NAVD 88) | Storage As-Built (ac-ft) | Storage Current 2024 (ac-ft) |
|---|---|---|---|---|
| | 308.00 | 308.13 | 0.0 | 0.0 |
| Reservoir bottom during ASI survey | 311.02 | 311.16 | 1.5 | 0.0 |
| | 312.00 | 312.13 | 2.0 | 1.5 |
| | 316.00 | 316.13 | 19.4 | 44.7 |
| | 320.00 | 320.13 | 93.2 | 130.2 |
| WSE at time of LiDAR Collection | 320.93 | 321.06 | 132.0 | 158.0 |
| Low Level Ports | 322.50 | 322.63 | 198.0 | 225.9 |
| | 324.00 | 324.13 | 290.0 | 314.2 |
| PS Crest Concept | 325.00 | 325.10 | 361.4 | 384.1 |
| PS Crest | 325.00 | 325.13 | 364.0 | 386.9 |
| Sediment Storage Concept | 325.10 | 325.23 | 373.2 | 394.9 |
| Sediment Storage (As-built) | 325.63 | 325.77 | 423.0 | 438.5 |
| | 328.00 | 328.13 | 644.0 | 667.7 |
| | 332.00 | 332.13 | 1150.2 | 1192.5 |
| AS Crest | 336.00 | 336.13 | 1844.0 | 1910.7 |
| | 340.00 | 340.13 | 2774.7 | 2848.4 |
| DC Effective | 342.10 | 342.23 | 3417.7 | 3441.8 |
| | 344.00 | 344.13 | 3999.5 | 4045.2 |
| | 346.00 | 346.13 | 4711.9 | 4753.9 |
| | 348.00 | 348.13 | 5424.3 | 5545.9 |

# 3. Hydrology and Hydraulics

A hydrology model for the Escondido Creek watershed was used to estimate flows for economic evaluation of the impacts of the considered alternatives. The recently completed Draft Karnes County Flood Protection Planning (FPP) (Doucet, 2023) was selected to use for this analysis, with edits as described below for the evaluation of Escondido Creek FRS No. 12 and the two concurrent Supplemental Watershed Planning efforts for FRS No. 1 and FRS No. 4 along Panther Creek and Doe Branch, respectively. These models are prepared by the River Authority a FEMA Cooperating Technical Partner (CTP).

## 3.1 Draft Karnes County Flood Protection Plan Background

The Draft Karnes County FPP model encompasses 55 subbasins for Escondido Creek and its tributaries, of which 19 subbasins were associated with the three study streams for the three dams: Panther Creek, Doe Branch, and Bucker Creek. The overall approach was to review and update all hydrologic inputs for the 19 subbasins associated with these three dams and three streams with the level of detail and methods commonly used for NRCS dam design. Outside of the detailed study area associated with Panther Creek, Doe Branch, and Bucker Creek, all subbasin parameters remain unchanged from the Draft Karnes County FPP, with the single exception of minor adjacent subbasins revisions for nine basins to match the revised watershed boundaries for this study. The Draft Karnes County model was an update to the model used to develop the 2007 DFIRM map (FEMA), which was also prepared by the River Authority using methods outlined in per the Draft San Antonio River Basin (SARB) Regional Modeling Standards for Hydrology and Hydraulic Modeling (the River Authority, 2018).

The final hydrologic models for Escondido Creek were not available at the time of this study. The River Authority concurred on the applicability of using these draft models for the economic evaluation of Escondido FRS No. 12. The draft models were reviewed by The River Authority and are close to the final version that will be used for the upcoming FEMA submittal.

There are two USGS gages on tributaries to the San Antonio River in the vicinity of Escondido Creek, 1) Gage 08186500 Ecleto Creek near Runge, TX, 2) Gage 08187500 Escondido Creek at Kenedy, TX. The Draft Karnes County FPP calibration focused on the Ecleto Creek gage, located approximately 8 miles northeast of the Escondido Creek gage, in close proximity to the study area. The Ecleto Creek flow gage has a long record spanning from 1903 to present day. The calibration effort used this record from 1903 to 2022 to perform a Bulletin 17B/17C model calibration. Additionally, storm event calibration was performed for four events in November 2002, March 2007, May 2015, and November 2018.

The calibration based on the Bulletin 17B analysis identified extreme streamflow events in 1903, 1952, 1967, and 1981 as "Historical" events, resulting in a 1% annual exceedance discharge of about 30,000 cfs, closely matching the HEC-HMS discharge of 29,000 cfs. The Bulletin 17C analysis, excluding pre-1962 records due to data gaps, initially indicated a 1% annual chance discharge of about 58,500 cfs using station skew, which is approximately double the HEC-HMS generated flow of 29,000 cfs. An alternative analysis based on TxDOT hydraulic Design Manual with a regional skew of 0.0 and MSE of 0.123 yielded a 1% annual chance discharge of approximately 42,000 cfs, which was within the 95% confidence interval. The Bulletin 17C analysis indicates that actual stream flow may be greater than the HEC-HMS predicted model flow.

For the storm event calibration, the Draft HEC-HMS model for Ecleto Creek overestimated the peak discharge for the November 2002 storm by approximately 41%, with the peak occurring 90 minutes earlier than observed, while for the March 2007 event, the peak discharge closely matched the observed value, although the peak time was later than observed. For the May 2015 and November 2018 events, the model underestimated peak discharges by 15% and 18%, respectively, with the peak times occurring more than 6 hours earlier and 90 minutes later than observed. On average, across all events, the modeled peak discharge was within 2% of the observed flow, and the time of peak was within 30 minutes of the observed peak (Doucet, 2023).

Based on the calibration results, the model parameters for the Ecleto Creek study area were considered representative of the entire study area. Since the same parameter development methods were applied across all watersheds, followed the procedures used in the development of the FEMA effective study, and aligned with the SARB regional modeling standards, no additional parameter adjustments were made by the River Authority. The Escondido Creek gage, recently installed in December 2015, does not have a sufficiently long record to perform a Bulletin 17B/17C analysis. Additional model calibration was not performed because additional watershed-wide parameter adjustments would not be reflective of the River Authority modeling approach for Karnes County and would only provide a minute amount of additional accuracy compared to the draft model.

## 3.2 Escondido FRS. No 12 Upstream Watershed

**Section 3.2** discusses the parameter development for the area upstream of FRS No. 12. All other subbasins evaluated in detail along Panther Creek, Doe Branch, and Bucker Creek are discussed in **Section 3.3**.

Within the focused study area for Escondido FRS No. 1, 4, and 12 hydrologic parameters, including basin area, curve number, and lag time were updated in the Karnes County FPP hydrologic model for use in economics evaluation of this watershed plan. These changes were made following NRCS National Engineering Handbook guidelines to ensure consistent modeling parameters across both concept design analysis (SITES runs) and flooding impact analysis (HMS models). The subbasin area updates were minor and consistent with the Karnes County FPP (Doucet, 2023). The curve number re-estimation and the percent impervious cover closely aligned with the Karnes County FPP hydrologic model (majority of changes being less than 1.5 CN value). The lag times were also reasonably consistent between models and are representative of the normal variation seen when using different lag time equations.

### 3.2.1 Subbasin Delineation

The FRS No. 12 is located approximately 4.8, 5.1, and 5.0 miles downstream of FRS Nos. 5, 6 and 7, respectively, in series. The uncontrolled drainage area upstream of FRS No. 12 and below FRS Nos. 5, 6 and 7 and controlled drainage area above FRS Nos. 5, 6 and 7 were delineated based on 2019 LiDAR topography (USGS, 2020) and aerial imagery to ensure the inclusion of roadways and hydraulic crossing structures (e.g., culverts, bridges). The contributing area based upon natural terrain was estimated to be 6.06 square miles for the uncontrolled drainage area and 5.58 square miles for the controlled drainage area. Combining these areas, the total contributing area is estimated to be 11.64 square miles using a combination of automatic delineation in GIS, engineering judgement, and hand edits.

### 3.2.2 Curve Number Loss Method

Curve numbers (CN) for Escondido Creek subbasins were estimated using the National Land Cover Database (NLCD) 2019 (Dewitz, 2021) and Soil Survey Geographic Database

(SSURGO) (USDA, 2023) soil data per the guidance provided in the Draft San Antonio River Basin (SARB) Regional Modeling Standards for Hydrology and Hydraulic Modeling (the River Authority, 2018), Table 3.4, National Land Cover, Land Use Classifications and Corresponding TR-55 Classifications. The curve numbers for each NRCS TR-55 classifications were taken from the National Engineering Handbook (NEH), Part 630 Hydrology, Chapter 9, Hydrologic Soil-Cover Complexes. The resulting curve number correlation is provided per **Table 3.1**.

The NCLD 2019 land use layer (Dewitz, 2021) was manually adjusted in two ways. To ensure the roadways were accurately depicted, existing roadway extents were clipped to the NLCD 2019 land cover layer based on the available Karnes County parcel data (TxGIO, 2023). Second, the land use assignments upstream of FRS No. 12 were compared to the most recent imagery and minor adjustments were made to the assigned land use code. The land use map for the area upstream of FRS No. 12 is presented in **Exhibit D-5**. The hydrologic soil groups for the drainage area are comprised of predominantly Type B, C, and D soils with minor inclusions of Type A soil (**Exhibit D-6**).

The percent impervious cover (%IC) was applied from San Antonio River Authority guidance provided on recent hydrologic studies (AECOM / Halff Associates, 2021 and 2022) where %IC is assigned to each NLCD code. The %IC assigned to each land use code is also provided in **Table 3.1**.

The area weighted curve number for the subbasin above Dam 12 is 76.29, the area weighted % IC is 10.41%, and the composite CN rounded to the nearest whole number is 79. For NRCS design, the average ARC curve number was adjusted per Figure 5A from the Engineering Technical Note No. 210-18-TX1 (USDA, 1982) to a value of 66.1. Therefore, an average ARC CN(II) of 66.1 was used for NRCS concept designs in setting the top of dam elevation.

**Table 3.1. Escondido Supplemental Watershed Planning Curve Number, Impervious Cover, and Manning's n Assignments**

| NLCD No. | Classification | NEH Chapter 9 Classification | Hydrologic Condition | Curve Number by Soil Type | | | | Impervious Cover %[c] | Assigned Manning's n | Notes |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | A | B | C | D | | | |
| 1[a.] | Road | Road | - | 98.0 | 98.0 | 98.0 | 98.0 | 100 | 0.050 | Roads from county parcel data; assigned % IC from land use code 24 |
| 11 | Open Water | Water | - | 98.0 | 98.0 | 98.0 | 98.0 | 100 | 0.038 | Draft SARB 2018 |
| 21[b] | Developed, Open Space | Open Space | Good | 39.0 | 61.0 | 74.0 | 80.0 | 20[c] | 0.040 | SARB 2019 (NLCD class 21 appears to be class 85 in Draft SARB Regional Modeling Standards for Hydrology and Hydraulic Modeling (2018)) |
| 22[b] | Developed, Low Intensity | Open Space with COSA impervious percentage for 1/4 to 1 acre residential | Good | 39.0 | 61.0 | 74.0 | 80.0 | 49[c] | 0.090 | Draft SARB 2018 |
| 23[b] | Developed, Medium Intensity | Open Space with COSA impervious percentage for 1/2 acre residential | Good | 39.0 | 61.0 | 74.0 | 80.0 | 79[c] | 0.120 | Draft SARB 2018 does not have a developed medium intensity category so treated the same as low / high intensity with appropriate %IC. |
| 24[b] | Developed, High Intensity | Open Space with COSA impervious percentage for 1/8 acre residential | Good | 39.0 | 61.0 | 74.0 | 80.0 | 100[c] | 0.160 | Draft SARB 2018 |
| 31 | Barren Land | Bare Soil / Newly Graded Areas | - | 77.0 | 86.0 | 91.0 | 94.0 | 0 | 0.025 | Draft SARB 2018 |
| 41 | Deciduous Forest | Woods | Fair | 36.0 | 60.0 | 73.0 | 79.0 | 0 | 0.150 | Draft SARB 2018 |
| 42 | Evergreen Forest | Woods | Fair | 36.0 | 60.0 | 73.0 | 79.0 | 0 | 0.120 | Draft SARB 2018 |
| 43 | Mixed Forest | Woods | Fair | 36.0 | 60.0 | 73.0 | 79.0 | 0 | 0.140 | Draft SARB 2018 |
| 52[b] | Shrub/Scrub | Brush (Brush-Forbs-Grass Mixture) / Brush Major Element | Fair | 35.0 | 56.0 | 70.0 | 77.0 | 0 | 0.038 | Draft SARB 2018 |
| 71 | Herbaceous/Grassland | Meadow | Good | 30.0 | 58.0 | 71.0 | 78.0 | 0 | 0.038 | Draft SARB 2018 |
| 81 | Pasture/Hay | Pasture (Pasture, Grassland, or Range) | Fair | 49.0 | 69.0 | 79.0 | 84.0 | 0 | 0.038 | Draft SARB 2018 |
| 82 | Cultivated Crops | Row crops (SR+CR) | Good | 64.0 | 75.0 | 82.0 | 85.0 | 0 | 0.035 | Draft SARB 2018 |
| 90[b] | Woody Wetlands | Woods | Good | 30.0 | 55.0 | 70.0 | 77.0 | 100 | 0.098 | Draft SARB 2018 |
| 95[b] | Emergent Herbaceous Wetlands | Meadows | Good | 30.0 | 58.0 | 71.0 | 78.0 | 100 | 0.068 | Draft SARB 2018 |

a. Roads w/right-of-way were overlain on the NLCD to ensure all roadways were captured and assigned a new land use code not listed in the SARB Regional Modeling Standards for Hydrology and Hydraulic Modeling (2018).

b. These NLCD categories have adjusted numbering since SARB Regional Modeling Standards for Hydrology and Hydraulic Modeling (2018) publication. The category numbers used align with the NLCD 2019 (Dewitz, 2021) codes and the classifications applied align with the SARB Regional Modeling Standards for Hydrology and Hydraulic Modeling (2018).

c. Impervious cover percentages were based upon the higher of the City of San Antonio (CoSA) average %IC per SARB Regional Modeling Standards for Hydrology and Hydraulic Modeling (2018) Table 3.2 or the more recent impervious cover guidance provided by the River Authority for 2019-2021 hydrologic modeling studies (AECOM / Halff Associates, 2021 and 2022) performed by AECOM. For NLCD codes 21 through 24, the %IC from the USAR and Medina studies was more conservative and used in this analysis.

### 3.2.3 Time of Concentration

The time of concentration ($T_c$) of the FRS No. 12 upstream subbasins were estimated using the NRCS Velocity Method, the NRCS Watershed Lag Method as described in NEH Part 630 Chapter 15 (NRCS 2010). The Velocity Method consists of the longest flow path broken up into sheet flow, shallow concentrated flow, and open channel flow segments. Each segment requires the length and slope as well as the land cover. Open channel geometry is needed for the channel segments as well. The Watershed Lag Method uses an empirical equation which requires the basin's watercourse length, average basin slope, CN, and subbasin area.

The Tc value of 3.14 hours for FRS No. 12 used in the hydrologic analysis is based on the Velocity Method. For comparison, the Tc value estimated by the Watershed Lag Method is 3.95 hours. The longest flow path used in this analysis is shown in **Exhibit D-2**.

A summary of the hydrologic inputs for Escondido FRS No. 5, FRS No. 6, FRS No. 7, and FRS No. 12 are presented in **Table 3.2.** The parameters used in previous hydrologic studies is also provided for comparison purposes only.

**Table 3.2. Hydrologic Inputs for FRS No. 5, FRS No. 6, FRS No. 7, and FRS No. 12**

| Parameter | AECOM (2024) | Dam Assessment (AECOM, 2014) | Draft Karnes County FPP (Doucet, 2023) |
|---|---|---|---|
| **Dam 5** | | | |
| Drainage Area (sq. mi.) | 1.34 | 1.36 | 1.34 |
| Curve Number (Type II) | 84 | 81.8 | 82.08 |
| Curve Number (Type II Adjusted) | 73.00 | 69.6 | NA |
| Time of concentration (hrs) | 0.62 | 0.90 | 1.07 |
| **Dam 6** | | | |
| Drainage Area (sq. mi.) | 2.41 | 2.49 | 2.32 |
| Curve Number (Type II) | 83 | 82.5 | 81.43 |
| Curve Number (Type II Adjusted) | 71.50 | 70.50 | NA |
| Time of concentration (hrs) | 1.47 | 1.62 | 1.58 |
| **Dam 7** | | | |
| Drainage Area (sq. mi.) | 1.82 | 1.75 | 1.87 |
| Curve Number (Type II) | 81 | 81.4 | 79.07 |
| Curve Number (Type II Adjusted) | 68.8 | 69.1 | NA |
| Time of concentration (hrs) | 1.62 | 0.88 | 0.97 |
| **Dam 12** | | | |
| Drainage Area (sq. mi.) | 5.71[a] | 6.04 | 5.72[a] |
| Curve Number (Type II) | 79 | 78.5 | 76.32 |
| Curve Number (Type II Adjusted) | 66.10 | 65.20 | NA |
| Time of concentration (hrs) | 3.14 | 2.70 | 3.45 |
| **BCK-002 (Below Dam 5)** | | | |

| Parameter | AECOM (2024) | Dam Assessment (AECOM, 2014) | Draft Karnes County FPP (Doucet, 2023) |
|---|---|---|---|
| Drainage Area (sq. mi.) | 0.05 | NA | 0.05 |
| Curve Number (Type II) | 86 | NA | 81.79 |
| Curve Number (Type II Adjusted) | 75.9 | NA | NA |
| Time of concentration (hrs) | 0.44 | NA | 0.30 |
| **BCK-004 (Below Dam 6)** | | | |
| Drainage Area (sq. mi.) | 0.15 | NA | 0.15 |
| Curve Number (Type II) | 85 | NA | 80.73 |
| Curve Number (Type II Adjusted) | 74.4 | NA | NA |
| Time of concentration (hrs) | 0.72 | NA | 0.56 |
| **BCK-006 (Below Dam 7)** | | | |
| Drainage Area (sq. mi.) | 0.15 | NA | 0.15 |
| Curve Number (Type II) | 75 | NA | 74.36 |
| Curve Number (Type II Adjusted) | 61 | NA | NA |
| Time of concentration (hrs) | 0.73 | NA | 0.58 |

NA = Not applicable

a. Hydrologic inputs for Dam 12 for Dam Assessment (AECOM, 2014) includes the three uncontrolled subbasins below Dams 5, 6, and 7.

### 3.2.4 Routing Reaches

The routing reaches for the Escondido Supplemental Watershed Planning study have been updated from the hydrologic model from the Draft Karnes County Flood Protection Planning (Doucet, 2023). Muskingum-Cunge method with an eight-point cross section reach routing method was used for Bucker Creek in the Draft Karnes County FPP. Data for the eight-point cross section, reach slope, and reach length were extracted using 2019 LiDAR topography (USGS, 2020). Aerial photography was evaluated to determine appropriate Manning's roughness values for the main channel, left overbank, and right overbank. These data were then input into the HEC-HMS model and are summarized in **Table 3.3**. The routing reaches between FRS Nos. 5, 6, 7, and FRS No. 12 used in this analysis are shown in **Exhibit D-2**. In SITES modeling, the reach between FRS Nos. 5, 6, 7, and FRS No. 12 was also modeled using the Muskingum-Cunge routing method. The input data for SITES, including representative cross section data, channel length, and valley length, were obtained from 2019 LiDAR topography.

**Table 3.3. Routing Reach Parameters for Panther Creek**

| Reach | Length (ft) | Slope | Manning's n | | | Index Celerity (ft/s) |
|---|---|---|---|---|---|---|
| | | | Channel | Left Overbank | Right Overbank | |
| R_ BCK-002 | 2,304 | 0.0063 | 0.04 | 0.035 | 0.035 | 5 |
| R_ BCK-004 | 3,423 | 0.0037 | 0.04 | 0.035 | 0.035 | 5 |
| R_ BCK-006 | 3,247 | 0.0054 | 0.04 | 0.035 | 0.035 | 5 |
| R_ BCK-007 | 15,915 | 0.0025 | 0.04 | 0.035 | 0.035 | 5 |

### 3.2.5 Precipitation

Point rainfall for the frequency storm analysis and the probable maximum flood (PMF) analysis was obtained from the following three sources:

- National Oceanic and Atmospheric Administration (NOAA) Atlas 14 Depth-Duration Frequency (DDF) Rainfall Values for Precipitation Area (PA) 8 from SARB Modeling Standards were used in frequency analysis in HEC-HMS. The PA-8 rainfall is used to be consistent with SARB Modeling Standards and are summarized in **Table 3.4**.
- NOAA Atlas 14, Volume 11, Version 2 (2018) rainfall depths was used for the 200-year storm event in frequency analysis, as SARB PA - 8 lacked data for this storm event. Rainfall values are summarized in **Table 3.5**.
- TCEQ Probable Maximum Precipitation (PMP) rainfall depths were estimated with the Applied Weather Associates, LLC (AWA) web application Texas Basin PMP Tool (TCEQ, 2023). A summary of the PMP rainfall values for the combined area contributing to FRS Nos. 5, 6, 7, and FRS No. 12 is presented in **Table 3.6**.

**Table 3.4. Escondido FRS No. 12 SARB NOAA Atlas 14 PA-8 Rainfall Values for Frequency Storm Modeling**

| Storm | Rainfall Depth (inches) for AEP Events | | | | | | |
|---|---|---|---|---|---|---|---|
| Duration | 50% | 20% | 10% | 4% | 2% | 1% | 0.2% |
| 5 minute | 0.53 | 0.65 | 0.76 | 0.90 | 1.02 | 1.13 | 1.37 |
| 10 minute | 0.85 | 1.04 | 1.21 | 1.44 | 1.63 | 1.81 | 2.17 |
| 15 minute | 1.07 | 1.31 | 1.51 | 1.79 | 2.02 | 2.24 | 2.71 |
| 30 minute | 1.50 | 1.83 | 2.11 | 2.49 | 2.80 | 3.10 | 3.77 |
| 1 hour | 1.96 | 2.40 | 2.78 | 3.31 | 3.73 | 4.15 | 5.13 |
| 2 hour | 2.39 | 3.09 | 3.55 | 4.31 | 4.92 | 5.56 | 7.18 |
| 3 hour | 2.65 | 3.51 | 4.03 | 4.97 | 5.72 | 6.53 | 8.67 |
| 6 hour | 3.07 | 4.01 | 4.85 | 6.08 | 7.10 | 8.23 | 11.34 |
| 12 hour | 3.48 | 4.57 | 5.58 | 7.11 | 8.40 | 9.87 | 14.10 |
| 24 hour | 3.92 | 5.16 | 6.37 | 8.22 | 9.78 | 11.60 | 16.93 |

**Table 3.5. Escondido FRS No. 12 NOAA Atlas 14 Rainfall Values for Frequency Storm Modeling**

| Storm Duration | 0.5% AEP Rainfall Depth (inches) |
|---|---|
| 5 minute | 1.24 |
| 10 minute | 1.98 |
| 15 minute | 2.46 |
| 30 minute | 3.42 |
| 1 hour | 4.60 |
| 2 hour | 6.28 |
| 3 hour | 7.47 |
| 6 hour | 9.54 |
| 12 hour | 11.6 |
| 24 hour | 13.7 |

**Table 3.6. Escondido FRS No. 12 TCEQ PMP Rainfall Values**

| Storm Duration (hr) | Combined Area Above Dams 5,6, and 7 Rainfall Depth (inches) | Combined Area Above Dam 12 Rainfall Depth (inches) |
|---|---|---|
| 1 | 11.6 | 11.5 |
| 2 | 20.4 | 18.5 |
| 3 | 22.3 | 21.3 |
| 6 | 28.6 | 27.3 |
| 12 | 35.6 | 35.3 |
| 24 | 42.8 | 42.4 |
| 48 | 46.0 | 45.7 |
| 72 | 46.0 | 45.8 |

## 3.3 Downstream Study Area

### 3.3.1 Project Setting and Data Sources

FRS No. 12 is located on Bucker Creek, contributing to Escondido Creek, a tributary of the San Antonio River. The Draft Karnes County FPP hydrologic model in Hydrologic Engineering Center Hydrologic Modeling System (HEC-HMS) Version 4.11 for Panther Creek, Doe Branch, and Bucker Creek tributaries was updated with revised drainage areas and hydrologic parameters.

New hydraulic (HEC-RAS) was created for the area upstream of the confluence of Bucker Creek upstream of the confluence at the connection with Escondido Creek. A hydrologic (HEC-HMS) model of the entire Escondido Creek was provided by the San Antonio River Authority. Updates made to the hydraulic models is further discussed in **Section 3.3.3**.

The following data sources were used in the development of these models:

- TNRIS, USGS Hurricane LiDAR. Published June 2020
- National Land Cover Dataset (NLCD) 2019 (Dewitz, 2021)
- SSURGO Soils
- Structure field measurements of private and public structures, provided by RESPECT.
- As-built plans for Escondido Creek FRS No. 12.

## 3.3.2 Hydrologic Analysis

### 3.3.2.1 Subbasin Delineation

FRS Nos. 5, 6, and 7 are located upstream and in series with FRS No. 12. The subbasin along Bucker Creek to the confluence with Escondido Creek was updated from the Draft Karnes County FPP model (Doucet, 2023). The study area downstream of FRS No. 12 along Bucker Creek and Escondido Creek was modeled in HEC-HMS Version 4.11. Like the subbasins above FRS No. 12, the subbasin boundaries on Bucker Creek were revised using the 2019 LiDAR and checked against current aerial imagery to ensure that the presence of roadways and hydraulic crossing structures (e.g., culverts, bridges) were captured properly. All subbasins for Panther Creek and Doe Branch for evaluation of FRS No. 1 and FRS No. 4, respectively, were also reviewed and updated.

Nine subbasins adjacent to the detailed study area were adjusted to align with the revised watershed boundaries used for this study. The area adjustments for adjacent Karnes County FPP (Doucet, 2023) subbasins are provided in **Table 3.7**. A map of the delineated Bucker Creek study area is presented in **Exhibit D-2.** The subbasin areas for Panther Creek, Doe Branch, and Bucker Creek subbasins are provided in **Table 3.8** and shown in **Exhibit D-3**. **Exhibit D-4** shows the Escondido Creek Watershed Planning detailed study area along with the Draft Karnes County FPP (Doucet, 2023) subbasins.

**Table 3.7. Drainage Areas for Adjacent Karnes County FPP Subbasins**

| Karnes County FPP Subbasin ID | Original Area (sq. mi.) | Revised Area (sq. mi.) |
|---|---|---|
| 3040110 | 3.847 | 3.837 |
| 3040112 | 3.114 | 3.119 |
| 3040113 | 1.952 | 1.960 |
| 3040116 | 0.117 | 0.117 |
| 3040201 | 3.830 | 3.789 |
| 3040205 | 0.712 | 0.702 |
| 3040215 | 0.979 | 0.977 |
| 3040218 | 3.533 | 3.531 |
| 3040221 | 0.613 | 0.611 |

### 3.3.2.2 Escondido Dam Rating Curves

The Escondido HEC-HMS model includes 13 NRCS dams, including FRS No. 12. Nine of these dams are situated within the portion of the Escondido Creek watershed under evaluation for the three concurrent Supplemental Watershed Planning studies: FRS Nos. 1, 2, 3, 4, 5, 6, 7, 12, and 13. FRS No. 2 and 13 are positioned within Panther Creek, FRS No. 3 and 4 are located along Doe Branch, and FRS Nos. 5, 6, 7, and 12 are situated within Bucker Creek and its tributaries.

The structural parameters for the six dams not under detailed evaluation as part of the Supplemental Watershed Planning effort were established utilizing available as-built plans and the most recent topographic data for the auxiliary spillway rating curve profile (FRS No. 2, 3, 5, 6, 7, and 13). No modifications to the HEC-HMS rating curves in the Karnes County FPP model were made to the remaining four dams outside the detailed study area (FRS No. 8, 9, 10, and 11). The elevation-storage relationship for the nine dams in the detailed study area were estimated based on the topographic data described in **Section 2.8**. The elevation-storage and storage-discharge rating curves were added to the HEC-HMS frequency storm analysis model.

#### 3.3.2.3 Curve Number Loss Method

Curve numbers within the Escondido Supplemental Watershed Planning study area were reevaluated using the CN correlation described in **Section 3.2.2**. The land use map is presented in **Exhibit D-5**. The hydrologic soil groups for the study area downstream of FRS No. 12 subbasin are comprised of predominantly Type B and Type C soils with minor inclusions of Type D and Type A soils (**Exhibit D-6**).

The CNs for all updated watersheds along Panther Creek, Doe Branch, and Bucker Creek are summarized in **Table 3.8**. In general, the CNs and %IC are similar or slightly higher than the Karnes County FPP, indicating good agreement between the two studies.

#### 3.3.2.4 Time of Concentration

The time of concentrations (Tc) for the remaining seven subbasins on Bucker Creek were estimated using the NRCS Velocity Method and the NRCS Watershed Lag Method as described in **Section 3.2.3**. A summary of the Velocity Method time of concentration analysis for the Supplemental Watershed Planning effort including Panther Creek (FRS No. 1), Doe Branch (FRS No. 4), and Bucker Creek (FRS No. 12) is presented in **Table 3.8**. The longest flow paths for Bucker Creek are shown in **Exhibit D-2**.

#### 3.3.2.5 Routing Reaches

The routing reaches downstream of FRS No. 12 along Bucker Creek, Doe Branch, and Panther Creek were revised from the Draft Karnes County FPP. No changes were made to the HEC-HMS routing reaches outside the detailed study area in the Karnes County FPP model.

The Karnes County FPP model utilizes two reach routing methods: Modified Puls where HEC-RAS hydraulic models are available (i.e., Panther Creek and Escondido Creek) and Muskingum-Cunge for all other streams. The Muskingum-Cunge routing method is applied to reaches along Doe Branch, Bucker Creek, and the segment between FRS No. 2 and the junction with Panther Creek. For these reaches, the 2019 LiDAR topography provided data for a representative 8-point cross-section, reach slope, and reach length. Aerial photography was used to determine Manning's roughness values for the left and right overbanks. These inputs were then used for routing in the HEC-HMS model, and the resulting routing parameters are presented in **Table 3.9**.

The Modified Puls routing method is utilized for four reaches along Panther Creek. For this method, 22 increasing discharges were used to estimate the storage-discharges relationship ranging from zero to a flow greater than the estimated 500-year discharge in each hydraulic model. The estimation of storage-discharge relationships was carried out using a customized spreadsheet, which uses the HEC-RAS results as input. The HEC-RAS results were also used.

**Table 3.8. Summary of Hydrologic Inputs for Panther Creek, Doe Branch, and Bucker Creek Subbasins**

| Name | Description | Area (sq. mi.) | Curve Number Loss Method | | | Transform Method | | |
|---|---|---|---|---|---|---|---|---|
| | | | CN (II) | % IC | Composite CN (II) w/IC | Longest Flow Path Length (feet) | Time of Concentration (hrs) | Lag Time (min) |
| **Bucker Creek** | | | | | | | | |
| BCK-001 | Above Dam 5 | 1.341 | 82.12 | 8.18 | 84 | 8559 | 0.62 | 22.32 |
| BCK-002 | Below Dam 5 | 0.053 | 82.37 | 21.08 | 86 | 2898 | 0.44 | 15.84 |
| BCK-003 | Above Dam 6 | 2.414 | 81.74 | 8.97 | 83 | 15129 | 1.47 | 52.92 |
| BCK-004 | Below Dam 6 | 0.147 | 82.68 | 16.31 | 85 | 5192 | 0.72 | 25.92 |
| BCK-005 | Above Dam 7 | 1.820 | 78.97 | 10.36 | 81 | 9713 | 1.62 | 58.32 |
| BCK-006 | Below Dam 7 | 0.155 | 74.41 | 2.36 | 75 | 4058 | 0.73 | 26.28 |
| BCK-007 | Above Dam 12 | 5.709 | 76.29 | 10.41 | 79 | 26961 | 3.14 | 113.04 |
| BCK-008 | Below Dam 12 | 0.945 | 72.40 | 8.01 | 75 | 15637 | 1.47 | 52.92 |
| **Doe Branch** | | | | | | | | |
| DOE-001 | Above Dam 3 | 4.559 | 75.84 | 5.25 | 77 | 19386 | 1.96 | 70.56 |
| DOE-002 | Above Dam 4 | 6.301 | 73.13 | 7.49 | 75 | 30587 | 2.95 | 106.2 |
| DOE-003 | Below Dam 4 | 0.886 | 74.28 | 19.49 | 79 | 15071 | 2.07 | 74.52 |
| **Panther Creek** | | | | | | | | |
| PAN-001 | Above Dam 1 | 3.216 | 70.03 | 3.71 | 71 | 14664 | 1.39 | 50.04 |
| PAN-002 | Below Dam 1 | 0.269 | 68.98 | 15.39 | 74 | 4902 | 0.45 | 16.20 |
| PAN-003 | Above Dam 2 | 2.404 | 68.87 | 7.29 | 71 | 13470 | 1.74 | 62.64 |
| PAN-004 | Below Dam 2 | 0.346 | 69.97 | 2.90 | 71 | 6860 | 1.06 | 38.16 |
| PAN-005 | Above Dam 13 | 4.591 | 73.75 | 6.71 | 76 | 18343 | 1.51 | 54.36 |
| PAN-006 | Below Dam 13 | 0.205 | 69.80 | 4.23 | 71 | 3078 | 0.66 | 23.76 |
| PAN-007 | Below Dam 13 | 0.087 | 66.86 | 21.73 | 74 | 4641 | 0.51 | 18.36 |

**Table 3.9. Routing Reach Parameters for Panther Creek, Doe Branch, and Bucker Creek**

| Reach | Length (ft) | Slope | Manning's n | | | Index Celerity (ft/s) |
|---|---|---|---|---|---|---|
| | | | Channel | Left Overbank | Right Overbank | |
| **Panther Creek** | | | | | | |
| R_ PAN-004 | 5370.66 | 0.0048 | 0.040 | 0.100 | 0.100 | 5 |
| **Doe Branch** | | | | | | |
| R_ DOE-003 | 13215.46 | 0.0028 | 0.040 | 0.050 | 0.070 | 5 |
| **Bucker Creek** | | | | | | |
| R_ BCK-002 | 2303.56 | 0.0063 | 0.040 | 0.035 | 0.035 | 5 |
| R_ BCK-004 | 3422.56 | 0.0037 | 0.040 | 0.035 | 0.035 | 5 |
| R_ BCK-006 | 3247.14 | 0.0054 | 0.040 | 0.035 | 0.035 | 5 |
| R_ BCK-007 | 15914.91 | 0.0025 | 0.040 | 0.035 | 0.035 | 5 |
| R_ BCK-008 | 11248.13 | 0.0020 | 0.040 | 0.050 | 0.050 | 5 |

to estimate the flow velocity in the main channel. The number of sub-reaches within each reach was estimated by assuming that the floodwave velocity is 1.5 multiplied by the channel velocity and by using a time step of 5 minutes.

#### 3.3.2.6 Precipitation and Areal Reduction

Precipitation depths from the combination of SARB Modeling Standards Precipitation Area (PA) - 8 and NOAA Atlas 14, Point Precipitation Frequency Estimates were used for the frequency storm analysis in hydrologic model as described in **Section 3.2.5**. The PA - 8 rainfall depths for the 50%, 20%, 10%, 4%, 2%, 1%, and 0.2% Annual Exceedance Probability (AEP) storm events were utilized. NOAA Atlas 14 rainfall depths were used for the 0.5% AEP storm event only to meet the requirement of eight storm events in the HEC Flood Damage Reduction Analysis (HEC-FDA) for economic analysis. The frequency storm events were compiled using a five-minute minimum storm intensity duration with peak intensity positioned at the center of the hyetograph (50%).

To account for areal reduction when the combined basin area exceeds 10 square miles in the HEC-HMS analysis, TP-40 area reduction was applied using the Depth-Area analysis option for key flow locations in the HEC-HMS model with greater than 10 contributing square miles. 36 Depth-Area analysis points, including subbasins, dams, and junctions, were selected for the depth area analysis for the eight AEP events listed above.

### 3.3.3 Hydraulic Analysis

Analysis for the Escondido Supplemental Watershed Planning studies used both 1D steady flow and 2D unsteady flow hydraulic models. Both 1D and 2D hydraulic models were developed in HEC-RAS version 6.3.0. The 1D steady flow hydraulic model is used for frequency analysis during the eight designated storm events while the 2D unsteady flow hydraulic model was used for NRCS sunny day dam breach analysis and inundation mapping.

#### 3.3.3.1 HEC-RAS 1D Frequency Storm Analysis

For FRS No. 12, HEC-RAS 1D model for Bucker Creek was created by AECOM. The HEC-RAS 1D model obtained from the Draft Karnes County FPP (Doucet, 2023) study was used as the starting point for the main stem Escondido Creek hydraulic model. Cross sections for the

Escondido Creek HEC-RAS model were extended to contain the higher discharge exhibited with the federal decommission alternative. Cross section locations for Bucker Creek and Escondido Creek are shown in **Exhibit D-7**.

All considered alternatives for detailed economic analysis (Alternative 1 - No Action, Alternative 2 - Decommission, and Alternative 3 – High Hazard Potential Rehab (Labyrinth Weir) were simulated in the 1D HEC-RAS model for the eight frequency storm events discussed in **Section 3.3.2.6**. Flow data from frequency storm analysis were utilized for subbasins with a drainage area less than or equal to 10 square miles, while results from the depth-area analysis runs were used for subbasins and junctions with an aggregate drainage area greater than 10 square miles.

For Bucker Creek, flow change locations were assigned via Excel spreadsheet using standard hydraulic modeling protocols, including flow changes at cross sections before roadway crossings, immediately downstream of dams, and one-third of the distance up a subbasin reach length from the outlet. For Escondido Creek, the flow change Excel spreadsheet from the Karnes County FPP effort was used to assign flows at the generally the same locations with minor updates. The flow assignments for the Bucker Creek and Escondido Creek HEC-HMS elements aligned to the 1D HEC-RAS cross section are presented in **Table 3.10**.

The crossings along Bucker Creek include those listed below:

- RS 9669 (Crossing Private AR)

The crossings along Escondido Creek were taken from the Draft Karnes County FPP. The crossings were reviewed, and the following crossings had Geoid adjustments from presumed Geoid 03 to Geoid 12B applied to the structure elevations:

- RS 117553 (Crossing CR 209)
- RS 112920 (Crossing CR 185)
- RS 101682 (Crossing CR 186)
- RS 95973 (Crossing FM 99)
- RS 84451 (Crossing FM 135)
- RS 53933 (Crossing US 181, Kenedy TX)
- RS 52239 (Crossing North 5$^{th}$ St, Kenedy TX)
- RS 47444 (Crossing FM 792, Helena RD, Kenedy, TX)

No changes from the Draft Karnes County FPP were made to the following crossings:

- RS 132920 (Crossing CR 210)
- RS 16296 (Crossing CR 331)
- RS 9606 (Crossing Private Road)

The downstream boundary condition for the Bucker Creek 1D HEC-RAS model was based on an estimated normal depth slope for the channel centerline, measured from the downstream cross section an equal distance both upstream and downstream. The Bucker Creek boundary condition was estimated at 0.001363 feet/feet. The boundary condition for Escondido Creek was unchanged from the Draft Karnes County FPP (Doucet, 2023).

## Table 3.10. HEC-RAS Flow Change Locations for Bucker Creek and Escondido Creek

| Hydrologic Element | DA (sq mi) | AECOM XS | Areally Reduced Peak Flow by Storm Event | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | 50% | 20% | 10% | 4% | 2% | 1% | 0.5% | 0.2% |
| **Bucker Creek** | | | | | | | | | | |
| SCS-Dam-12 | 11.64 | 11187 | 158 | 171 | 182 | 509 | 1670 | 3610 | 6250 | 10300 |
| Culvert | 11.79 | 10154 | 197 | 246 | 290 | 620 | 1680 | 3630 | 6280 | 10300 |
| J_BCK-008 | 12.58 | 5681 | 406 | 640 | 857 | 1200 | 1740 | 3710 | 6390 | 10500 |
| **Escondido Creek** | | | | | | | | | | |
| Headwater Input | 0.17 | 140185 | 78 | 114 | 146 | 192 | 228 | 267 | 308 | 360 |
| C3040101 | 2.31 | 135695 | 1070 | 1560 | 1980 | 2610 | 3100 | 3620 | 4180 | 4890 |
| SCS-Dam-9 | 6.96 | 124136 | 27 | 28 | 30 | 31 | 425 | 1240 | 2450 | 4440 |
| C3040103 | 7.36 | 118529 | 253 | 364 | 463 | 607 | 722 | 1280 | 2530 | 4570 |
| C3040104 | 8.63 | 114801 | 799 | 1160 | 1490 | 1980 | 2430 | 2900 | 3400 | 5010 |
| C3040105A | 9.24 | 109255 | 900 | 1380 | 1850 | 2530 | 3070 | 3650 | 4270 | 5250 |
| C3040105 | 14.18 | 106828 | 1850 | 2820 | 3640 | 4980 | 6050 | 7210 | 8490 | 10200 |
| C3040107 | 15.19 | 104295 | 1950 | 3010 | 3920 | 5580 | 6800 | 8120 | 9580 | 11500 |
| C3040108 | 17.47 | 97544 | 2250 | 3530 | 4660 | 6870 | 8480 | 10200 | 12000 | 14500 |
| C3040109A | 18.05 | 92146 | 2240 | 3540 | 4730 | 6920 | 8600 | 10400 | 12300 | 14900 |
| C3040109 | 22.44 | 89581 | 2280 | 3610 | 4840 | 7100 | 8840 | 10700 | 12700 | 15400 |
| C3040112 | 25.56 | 86584 | 2530 | 4050 | 5610 | 8250 | 10400 | 12600 | 15200 | 18500 |
| C3040113A | 27.52 | 81132 | 2650 | 4300 | 6000 | 8820 | 11100 | 13600 | 16400 | 20300 |
| C3040113 | 30.61 | 78389 | 2660 | 4310 | 6020 | 8850 | 11200 | 13700 | 16500 | 21100 |
| C3040116A | 30.72 | 77002 | 2650 | 4300 | 6000 | 8820 | 11100 | 13600 | 16500 | 21200 |
| C3040116 | 43.31 | 75012 | 2760 | 4400 | 6110 | 8930 | 11300 | 13800 | 18600 | 28100 |
| C3040201A | 47.1 | 67278 | 2860 | 4710 | 6620 | 9700 | 12300 | 15200 | 19800 | 30000 |
| C3040201 | 58.84 | 62637 | 2910 | 4750 | 6660 | 9750 | 12400 | 15300 | 21900 | 35900 |
| C3040205A | 59.54 | 60350 | 2900 | 4720 | 6650 | 9750 | 12400 | 15300 | 21800 | 35800 |
| C3040205 | 70.66 | 58488 | 2970 | 4770 | 6690 | 9750 | 12400 | 15300 | 21500 | 39200 |
| C3040215 | 71.64 | 55296 | 2980 | 4750 | 6680 | 9740 | 12400 | 15300 | 21400 | 39200 |
| C3040216 | 71.71 | 53265 | 2960 | 4720 | 6630 | 9680 | 12300 | 15200 | 21300 | 39200 |
| C3040217A | 75.52 | 48713 | 3040 | 4760 | 6690 | 9820 | 12500 | 15600 | 22000 | 40000 |
| C3040217 | 81.22 | 46411 | 3220 | 5030 | 7140 | 10500 | 13500 | 16800 | 23100 | 41700 |
| C3040224A | 83.99 | 39711 | 3260 | 5130 | 7290 | 10800 | 13800 | 17200 | 23500 | 42300 |
| C3040224 | 87.23 | 35798 | 3350 | 5290 | 7550 | 11200 | 14400 | 17900 | 24200 | 43400 |
| C3040301A | 88.91 | 32538 | 3340 | 5280 | 7510 | 11200 | 14400 | 18000 | 24300 | 43400 |
| C3040301 | 103.62 | 29333 | 3540 | 5620 | 8020 | 12000 | 15500 | 19400 | 25700 | 45200 |
| C3040304 | 109.12 | 21394 | 3580 | 5750 | 8170 | 12300 | 15900 | 20200 | 26800 | 45900 |
| C3040305 | 111.28 | 12245 | 3600 | 5790 | 8230 | 12300 | 16000 | 20400 | 27000 | 46200 |
| C3040306 | 113.07 | 3402 | 3600 | 5820 | 8270 | 12400 | 16100 | 20500 | 27300 | 46200 |

#### 3.3.3.2 HEC-RAS 2D Sunny-Day Breach Analysis

Technical Release No. 210-60 (TR-210-60) Earth Dams and Reservoirs (USDA NRCS, 2005) and TR-66 Simplified Dam-Breach Routing Procedure (NRCS SCS, 1985) breach criteria and procedures were used to estimate a breach discharge hydrograph. Fair weather conditions were assumed for the sunny day breach analyses, resulting in a peak discharge of 37,800 cfs. The initial reservoir pool elevation assumed for the breach scenario was static at top of dam with non-storm conditions downstream. The HEC-RAS 2D model was used to map the breach extent downstream of FRS No. 12.

The 2D HEC-RAS model for FRS No. 12 includes approximately 10.12 square miles of 2D flow area. Several breaklines were added along the crown of major roads and other elevated features such as existing dams and elevated channel banks to better define the terrain. Additionally, five SA/2D connections were incorporated to represent culverts and bridges along Bucker Creek and Escondido Creek. Two of the five crossings were situated on Bucker Creek, while the remaining crossings were located on Escondido Creek. All these crossings utilized in the 2D HEC-RAS model were aligned with structures used in the 1D HEC-RAS. The geometry of the structures, including bridge openings, pier dimensions, culvert sizes, and lengths from the 1D HEC-RAS, was applied to the 2D flow area with the help of the SA/2D connection data editor. The terrain was created from LiDAR dataset and aerial imagery. Manning's values were assigned based upon land used codes (as discussed in **Section 3.3.2.3**) per **Table 3.1**.

The inflow hydrographs for 2D analysis were applied as the upstream boundary condition for all three breach scenarios evaluated (i.e., static, hydrologic, and seismic) at the downstream toe of the dam. For the FRS No. 12 2D HEC-RAS model, the downstream normal depth was estimated to be 0.003 feet/feet downstream of Kenedy, Texas.

The work areas use a base cell size of 100-foot, with 50-foot cells along prominent breakline features to define roads, railroads, embankments, and other high-ground features within the inundation boundary. Where necessary, refinement regions were added using a 40-foot cell size.

The hydraulic model was run using the full momentum, Shallow Water Equation – Eulerian-Lagrangian Method (SWE-ELM) equation set with a fixed time step of 5 seconds for a 24-hour simulation window. The model runs with a 1-minute mapping output interval, a hydrograph output interval of 1-minute, and 1-minute detailed output interval.

Using the results of the sunny day breach analysis, the population at risk (PAR) was estimated for the existing condition (i.e., with existing dam in place). Note that estimating the PAR is based on professional judgment coupled with empirical data. PAR estimates were provided for motorists, residents, and other people located downstream that could be affected by flooding from a catastrophic failure of FRS dam.

Guidance for Completion of "Evaluation of Potential Rehabilitation Projects" December 10, 2001, Updated January 2021 was utilized to estimate PAR for residences and motorists downstream of the dam. According to the guidance, three people per residence are estimated to be at risk where floodwaters are greater or equal to 1.0 foot above natural ground elevation. For paved roads with predominantly local traffic, one vehicle per road with two people per vehicle are estimated to be at risk where floodwaters overtop the road deck at a depth of greater than or equal to 1.0 foot.

The PAR for FRS No. 12 during a sunny day breach was estimated to be 144. All rehabilitation options considered would eliminate or greatly reduce the risk to the population downstream to an acceptable level.

#### 3.3.3.3 HEC-RAS FBH Storm Event Breach Analysis

FRS Nos. 5, 6, and 7 can safely pass the FRS No. 12 FBH storm events (6-hour and 24-hour FBH) without overtopping. Therefore, the FBH storm event breaches of FRS Nos. 5, 6, and 7 and their impact on FRS No. 12 was not evaluated.

## 3.4 SITES Analysis

### 3.4.1 SITES Modeling for Existing Condition

The dam hydrologic and hydraulic SITES Integrated Development Environment (SITES) Version 2005.1.12 (USDA, 2022) was used to evaluate erosional stability and head-cutting potential for a vegetated auxiliary spillway channel subjected to flows associated with the design storm events. AECOM has performed a preliminary geologic investigation to evaluate the existing vegetated auxiliary spillways. Four soil borings were collected as part of the geotechnical subsurface investigation for the left spillway: 201-23, 202-23, 203-23, and 204-23. Development of recommended geologic input parameters for SITES analysis was performed according to published NRCS guidance (NRCS 2001, NRCS 2011) and other publications (McCook, 2005).

The SITES parameters recommended for the existing conditions analysis are summarized In **Table 3.11.** Detailed discussion of the analysis assumptions, methodology, and results is provided in **Appendix E-7** of the Supplemental Watershed Plan No. III and Environmental Assessment for the Rehabilitation of Floodwater Retarding Structure No. 12 of the Escondido Creek Watershed, Recommended Geologic Input Parameters for SITES Analysis (AECOM 2024). The rainfall values used in the FRS No. 12 SITES existing conditions and alternative analysis are provided in **Table 3.12**.

**Table 3.11. Recommended Representative Material Parameters for SITES Analysis**

| SITES Inputs | Proposed Fill (ASW Borrow) (CL - Lean Clay) | Existing Fill (CL – Sandy Clay) | Alluvium / Residuum (CH – Fat Clay) | Oakville - Sandy Clay (CL – Sandy Clay) | Oakville – Clayey & Silty Sands (SC – Clayey Sand) | Oakville - Clays (CH – Fat Clay) |
|---|---|---|---|---|---|---|
| Plasticity Index (PI) - Representative | 30 | 15 | 30 | 21 | 17 | 38 |
| Dry Density (lbs/ft$^3$) – Representative | 92 | 97 | 100 | 115 | 90 | 102 |
| Kh – Representative | 0.10 | 0.10 | 0.20 | 0.20 | 0.20 | 0.30 |
| Clay % – Representative | 25 | 17 | 24 | 24 | 5 | 24 |
| Rep. Diam. D75 (mm) – Representative | 0.06 | 0.11 | 0.085 | 0.12 | 0.22 | 0.05 |
| Rep. Diam. D75 (in) – Representative | 0.0024 | 0.0043 | 0.0033 | 0.0047 | 0.0087 | 0.0020 |

**Table 3.12. Escondido FRS No. 12 Rainfall Values for NRCS Design**

| Storm Event | Source | Rainfall Depth (inches) |
|---|---|---|
| 50-yr, 24-hour | NOAA Atlas 14, Volume 11, Version 2 | 9.78 |
| 50-yr, 10-day | | 14.40 |
| 100-yr, 6-hour | | 8.22 |
| 100-yr, 24-hour | | 11.60 |
| 100-yr, 10-day | | 16.80 |
| PMP 6-hr / (FBH) | TCEQ PMP GIS Tool | 27.30 |
| PMP 12-hr | | 35.30 |
| PMP 24-hr / (FBH) | | 42.40 |
| SDH 6-hr | TR-210-60 Figure 2-2 | 13.19 |

The combined 1-day/10-day 100-year Principal Spillway Hydrograph (PSH) run indicates that a peak WSE of 339.9 feet is achieved, assuming the auxiliary spillways do not engage. Since the as-built auxiliary spillway crest is at elevation 336.13 feet, this peak WSE indicates that the auxiliary spillways would engage, which does not meet the NRCS criteria for a high hazard potential structure. The drawdown time after the passage of the PSH was estimated as more than 11.44 days, which does not meet the NRCS evacuation criteria of passing 85% of the floodpool within 10 days.

The 6-hour Stability Design Hydrograph (SDH) rainfall value of 13.19 inches was used to evaluate the stability of the vegetated auxiliary spillway. The stability evaluation was performed following the guidance of Agricultural Handbook #667, Stability Design of Grass-Lined Open Channels (USDA ARS 1987). The auxiliary spillway is considered to have two main soils, CL-Sandy Clay and CH – Fat Clay and a good vegetation cover with a vegetal retardance curve index of 5.6. The maximum SITES effective soil stress and total stress for the FRS No. 12 existing auxiliary spillway are 0.644 pounds per square foot (psf) and is 2.82 psf, respectively. These results exceed the allowable soil stress of 0.088 psf and 0.187 psf, for CL and CH soil types respectably but do not exceed the vegetal stress of 4.2 psf. These results suggest that soil erosion will probably occur even though vegetation is stable. Therefore, the existing auxiliary spillway does not meet the NRCS stability requirements.

The existing auxiliary spillway was evaluated for headcut development and advancement during the 24-hour Freeboard Design Hydrograph (FBH). Preliminary SITES integrity analysis for the existing spillway using the representative soil parameters (i.e., typically between the true average and the lower one-third value of the dataset) indicates that extensive headcutting with full breaching of the auxiliary spillway will occur. The auxiliary spillway headcutting plots during the 24-hour FBH is presented in **Figure 3.1**.

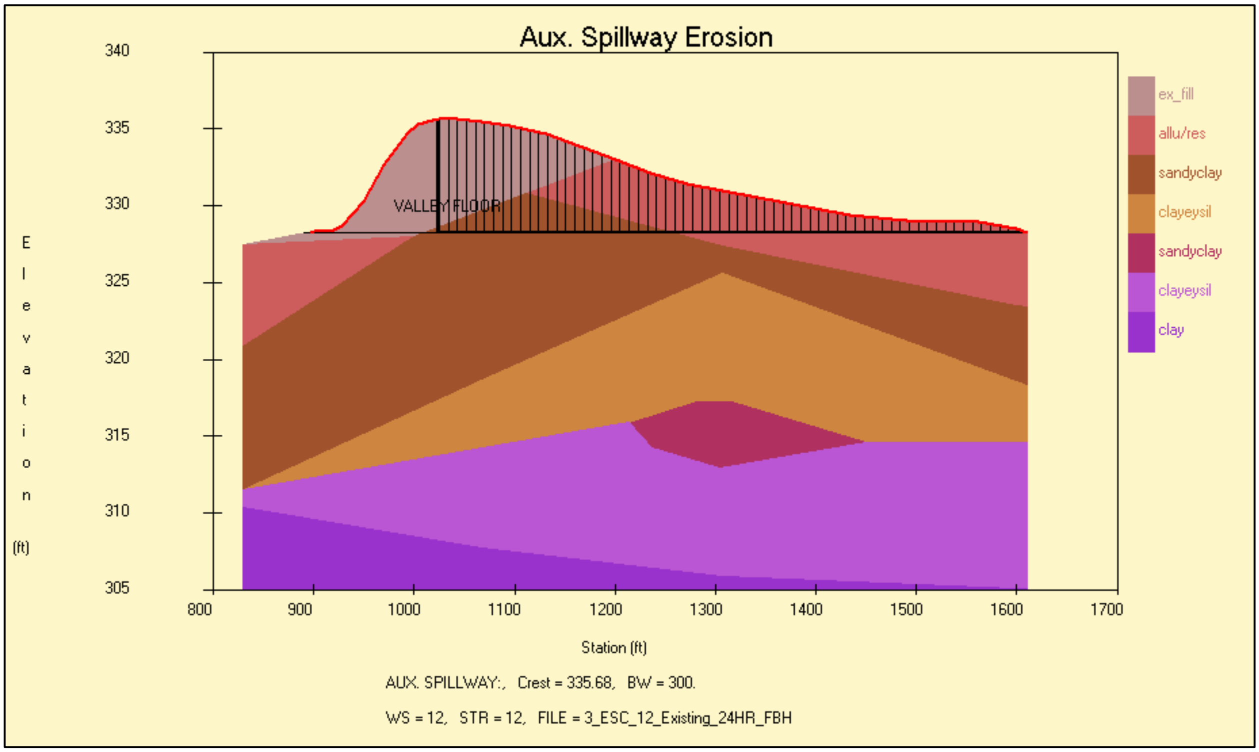


**Figure 3.1 Existing Auxiliary Spillway Integrity Analysis Results**

### 3.4.1.1 SITES Modeling for Upstream Dams

Three upstream dams - Escondido FRS Nos. 5, 6, and 7 - were analyzed individually during the evaluation of FRS No. 12 to assess their performance under 6-hour and 24-hour FBH events. Since these upstream dams have smaller drainage areas compared to total contributing area to FRS No. 12, the TCEQ PMP rainfall values are slightly higher (i.e. not areally reduced), as shown in **Table 3.6**. The peak WSE in FRS Nos. 5 and 7 remained below the effective top of dam elevation during 6-hour and 24-hour FBH events. However, FRS No. 6 achieved a peak WSE slightly higher than the existing effective top of dam elevation by 0.12 feet during the 6-hour FBH (**Table 3.13**) only. The slight overtopping, along with the presence of a low spot on the Dam 6 embankment as shown in **Figure 3.2**, was discussed with Sponsors and the NRCS, who agreed that minor re-grading on the embankment would be an appropriate solution. This would be a minor repair to the dam, as the majority of the embankment length exceeds the as-built effective top of dam elevation.

When these same three upstream dams were evaluated with the lower, areally reduced FBH appropriate for evaluation of the larger contributing area to FRS No. 12, all three dams had peak WSE below the effective top of dam (**Table 3.13)** due to the lower point rainfall values, per **Table 3.6**. Under these conditions, none of the upstream dams overtopped during the 6-hour and 24-hour FBH analyses. Due to the upstream dams having hydrologic capacity to pass the NRCS designs storms for FRS No. 12, the concept design analysis of FRS No. 12 did not breach the upstream dams; the dams were modeled in their existing condition.

**Table 3.13. FRS Nos. 5, 6, and 7 Peak WSE During 6-hr and 24-hr FBH events**

| Upstream Dams | Existing Effective Top of Dam (ft) | Peak WSE Considering Higher PMP Values (for FRS Nos. 5, 6, and 7 only) | | Peak WSE Considering Lower PMP Values (for FRS No. 12) | |
|---|---|---|---|---|---|
| | | 6-hr FBH (ft) | 24-hr FBH (ft) | 6-hr FBH (ft) | 24-hr FBH (ft) |
| FRS No. 5 | 409.09 | 408.95 | 406.74 | 408.62 | 406.62 |
| FRS No. 6 | 418.70 | **418.82** | 418.02 | 418.58 | 417.87 |
| FRS No. 7 | 412.29 | 410.87 | 410.74 | 410.61 | 410.58 |

**Bolded** value exceeds the datum adjusted existing effective top of dam elevation.

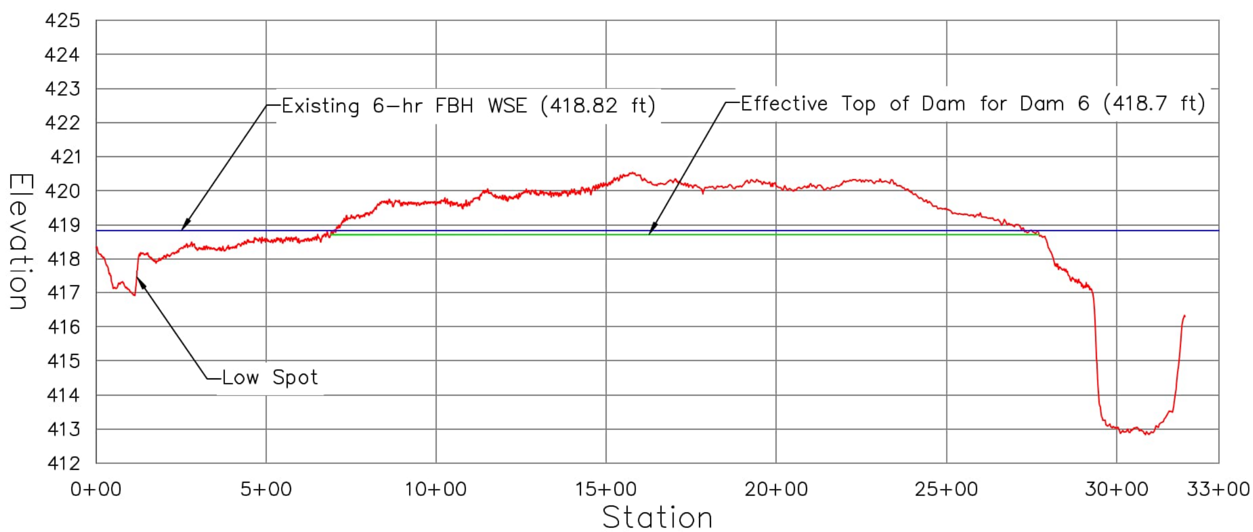


**Figure 3.2 Existing Top of Dam Profile for FRS No. 6**

## 3.4.2 SITES Modeling for Alternative 3

The dam hydraulic and hydrologic computer analysis program SITES was used to:

- Develop design inflow hydrographs for all contributing upstream watersheds;
- Develop storage-discharge relationships for FRS No. 12 as well as upstream FRS Nos. 5, 6, and 7;
- Model the PSH to set the crest of the structural and vegetative auxiliary spillways;
- Model the Stability Design Hydrograph (SDH) and the Freeboard Design Hydrograph (FBH) events;
- Evaluate integrity/stability of the proposed vegetated auxiliary spillway;
- Evaluate wave run up height above the SDH peak WSE, and
- Set the top of dam elevation.

The 50-year and 100-year PSH events were evaluated to select the new size of the principal spillway and set the crest of the labyrinth weir and vegetative auxiliary spillway. The SITES PSH results are provided in **Table 3.14**. The main goals in sizing this principal spillway system include:

- Safely pass the 1% PSH peak flow with no increase to the existing condition peak 1% PSH flow. The 1% AEP flow is also checked in the HEC-HMS frequency storm analysis.
- Select a crest elevation of the principal spillway riser tower that provides 100 years of future submerged sediment storage (discussed in **Section 2.9**).

Note that the existing principal spillway has a “squat” drop inlet riser design at only 9 feet tall. Per discussion with NRCS, the design of the second new principal spillway riser can maintain a similar hydraulics design proportioning to keep the principal spillway crest at the same elevation.

Two rainfall events evaluated for estimating the peak water surface elevation and setting the top-of-dam crest elevation, including the 6-hour PMP storm with a rainfall depth of 27.30 inches and the 24-hour PMP storm with a rainfall depth of 42.40 inches. The 24-hour PMP storm proved to be the most conservative design storm in setting the top of dam elevation for the high hazard rehabilitation option with a peak water surface elevation of 343.8 feet. The SITES output for Alternative 3 is provided in **Table 3.15**.

Wave setup and wave runup were factored into the analyses in accordance with NRCS procedures (TR-56). The combined wave setup and runup for FRS No. 12 were estimated at 5.3 feet at the SDH peak WSE of 340.0 feet. The resulting maximum WSE is 345.30 feet, or 3.07 feet above the existing top of dam elevation of 342.23 feet. The wave runup evaluation results for Alternative 3 are also provided in **Table 3.15**.

The Alternative 3 effective top of dam elevation is set at 345.3 feet based upon the higher peak water surface elevation achieved during the FBH event versus the additional freeboard required for wind and wave action above the SDH elevation. For FRS No. 12, the governing criteria were the wave runup evaluation, setting the top of dam at 345.3 feet.

**Table 3.14. Escondido FRS No. 12 SITES PSH Results – Alternative 3**

| SITES Parameter | 50-YR PSH High Hazard Concept Design | 100-YR PSH High Hazard Concept Design |
|---|---|---|
| Site Identification | 12 | 12 |
| Watershed Runoff Curve Number | 79 | 79 |
| Climatic Index for Karnes County | 0.57 | 0.57 |
| Total Watershed Drainage Area (Sq. Miles) | 11.64 | 11.64 |
| Watershed Time of Concentration (Hours) | 3.14 | 3.14 |
| Initial Reservoir Elevation (Feet) | 325.23 | 325.23 |
| PSH Drawdown (Days) | 7.75 | 7.79 |
| PS 1 Crest (Feet) | 325.1 | 325.1 |
| PS 2 Crest (Feet) | 325.13 | 325.13 |
| PS Number of Conduits | 2 | 2 |
| PS Conduit Diameter (Inches) | 42 | 42 |
| PS Conduit Area (Sq. Feet) | 19.24 | 19.24 |
| Storage, PS Crest (Acre-Ft) | 384 | 384 |
| PS Discharge at AS Crest (CFS) | 359.0 | 658.2[1] |

| SITES Parameter | 50-YR PSH High Hazard Concept Design | 100-YR PSH High Hazard Concept Design |
|---|---|---|
| AS Crest (Feet) | 335.85 | 338.37 |
| Storage, AS Crest (Acre-Ft) | 1851.9 | 2406.2 |
| Uncontrolled Drainage Area (Sq. Miles) | 5.71 | 5.71 |

1/ Total PS discharge from FRS No.12 is 658.2 cfs (386.2 cfs from two 42-inch principal spillway conduits and 272.0 cfs from 180-foot labyrinth weir).

### Table 3.15. Escondido FRS No. 12 SITES SDH/FBH Results – Alternative 3

| SITES Parameter | 6-hr SDH/FBH | 24-hr FBH |
|---|---|---|
| Site Identification | 12 | 12 |
| Watershed Runoff Curve Number | 66 | 66 |
| Total Watershed Drainage Area (Sq. Miles) | 11.64 | 11.64 |
| Watershed Time of Concentration (Hours) | 3.14 | 3.14 |
| SDH Rainfall Total (Inches) | 13.19 | N/A |
| SDH Rainfall Duration (Hours) | 6 | N/A |
| FBH or Storm Rainfall Total (Inches) | 27.30 | 42.40 |
| FBH or Storm Rainfall Duration (Hours) | 6 | 24 |
| SDH Inflow Peak (CFS) | 9101.8 | N/A |
| FBH or Storm Inflow Peak (CFS) | 33882.0 | 32002.9 |
| Initial Reservoir Elevation (Feet) | 325.23 | 325.23 |
| Maximum WS SDH (Feet) | 339.93 | N/A |
| Maximum WS FBH or Storm (Feet) | 343.51 | 343.80 |
| Storage at Max. WS FBH or Storm (Acre-Ft) | 3843.2 | 3936.0 |
| Top Dam (Feet) | 343.51 | 343.80 |
| Storage, Top Dam (Acre-Ft) | 3840.0 | 3934.0 |
| PSH Drawdown (Days) | N/A | N/A |
| PS Crest (Feet) | 325.1 | 325.1 |
| PS 1 Conduit Diameter (Inches) | 42 | 42 |
| PS 2 Conduit Diameter (Inches) | 42 | 42 |
| Storage, PS Crest (Acre-Ft) | 384 | 384 |
| PS Discharge at AS Crest (CFS) | 1208.4 | 1208.4[1] |
| PS Discharge for SDH (CFS) | 5638.0 | N/A |
| PS Discharge FBH or Storm (CFS) | 20867.6 | 22019.9 |
| AS Crest (Feet) | 338.7 | 338.7 |
| Storage, AS Crest (Acre-Ft) | 2485.9 | 2485.9 |
| AS Width (Feet) | 300 | 300 |
| AS Max. Head SDH (Feet) | 2.79 | N/A |
| AS Peak Discharge SDH/Storm (CFS) | 482.5 | N/A |
| AS Exit Velocity SDH or Storm (Ft/S) | 2.68 | N/A |
| AS Peak Discharge FBH/Storm (CFS) | 8542 | 9420 |
| **Wave Run-Up Evaluation** | | |
| Effective Fetch (Miles) | 0.565 | - |

| SITES Parameter | 6-hr SDH/FBH | 24-hr FBH |
|---|---|---|
| Wave Setup (Ft) | 0.179 | - |
| Wave Runup (Ft) | 5.12 | - |
| Total Residual Freeboard (Ft) | 5.3 | - |
| Upper Limit Wave Protection (Ft) | 345.3 | - |

1/ Peak principal spillway discharge includes combined discharges from principal spillway and labyrinth weir.

#### 3.4.2.1 Habitable Structures Behind Dam

There are two habitable structures below the top of dam with Alternative 3. There is a relatively new pier and beam house (built in last few years, approximately 2018 or later) close to the left side of the embankment with surveyed finished floor elevation (FFE) of 339.19 feet (**Exhibit D-8**). This structure is reported to be a seasonal use structure with no full-time occupancy. The as-built auxiliary spillway crest (datum adjusted) is 336.13 feet and the existing peak 100-year PSH elevation is 337.41 feet, both below the FFE.

With Alternative 3, the vegetated auxiliary spillway crest (at 338.7 feet) and 100-year PSH peak WSE of 338.37 feet are both below the FFE of 339.19 feet. The economic modeling performed for this Supplemental Plan-EA indicates that the peak WSE during the 1% AEP storm event is at 339.27 feet, or 0.08 feet above this FFE. Alternative 3 will be updated accordingly during final design to confirm no flooding during the 100-year events.

The Draft Karnes County FPP model (Doucet, 2023) will likely progress to development of the effective Federal Emergency Management Agency (FEMA) floodplain. This model, for reference, indicates the peak WSE for the following scenarios, also both lower than the surveyed FFE of 339.19 feet:

- Base model, existing conditions, peak WSE in FRS No. 12 = 338.25 feet
- Base model, w/FRS No. 12 Alternative 3 rating curve, peak WSE in FRS No. 12 = 339.0 feet.

There are also multiple habitable structures (**Exhibit D-8**) located west of FM 1353 currently above the effective top of dam elevation of 342.23 feet. With Alternative 3, the effective top of dam elevation will be raised to 345.30 feet. Within this grouping of structures, it is estimated that there are three habitable structures near the rehabilitated top of dam, listed below with their estimated FFEs:

- Structure 2 FFE = 343.8 feet
- Structure 3 FFE = 348.8 feet
- Structure 4 FFE = 348.6 feet

Currently all three estimated FFEs are above the existing effective top of dam elevation. With Alternative 3, the estimated FFE of one structure may lie below the top of dam elevation set at 345.3 feet but just at the peak FBH WSE of 343.8 feet. A structure FFE survey may be performed to confirm these FFE elevations prior to final design. This information will be used to verify that these structures will not be flooded above the FFE during the final design FBH evaluation.

### 3.4.3 Integrity Analysis Alternative 3

An integrity analysis was performed for the Alternative 3 raised auxiliary spillway parameters using the geotechnical parameters provided in **Table 3.11**. The results of the integrity analysis indicate that the spillway does not breach during the 24-hour FBH using the estimated SITES parameters. No headcut was formed in spillway for Alternative 3 during the 24-hour FBH as presented in **Figure 3.3**. This improved performance compared to the existing condition is attributed to the flow capacity of the labyrinth weir which alleviates the impact on the vegetated spillway. The soil parameters used in the integrity analysis may be refined during final design following additional subsurface investigation.

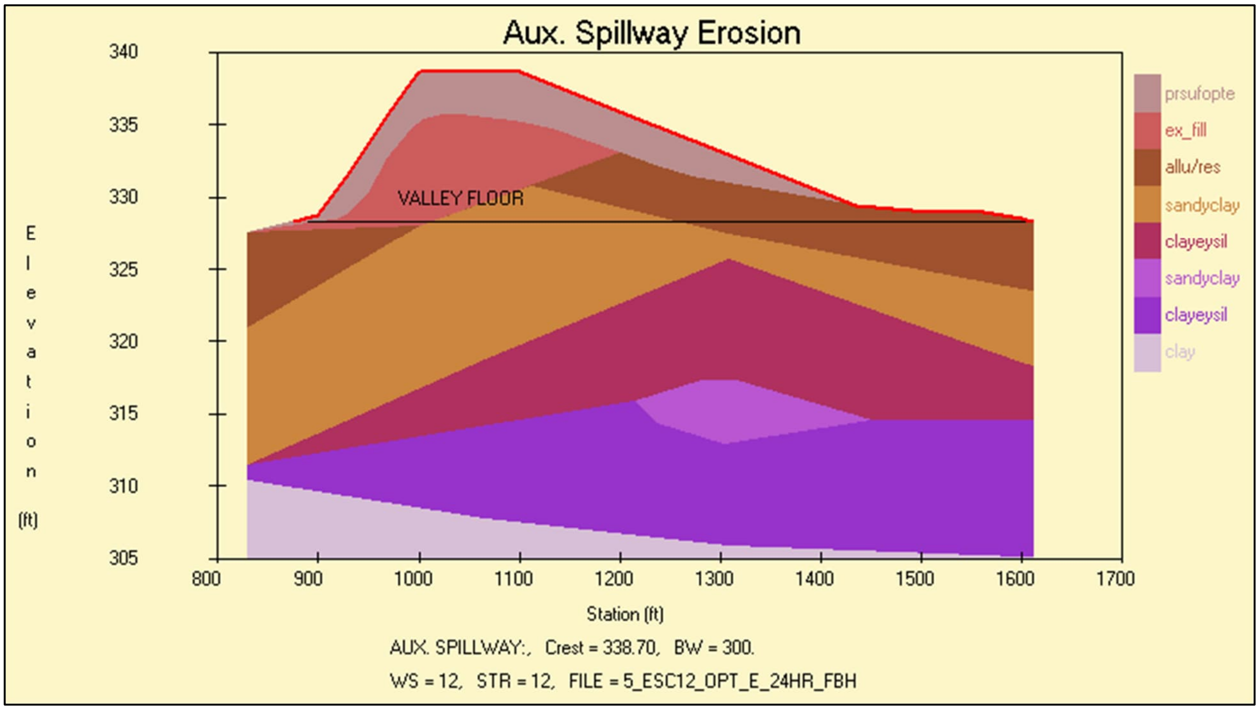


**Figure 3.3 Alternative 3 - 24-hour FBH**

### 3.4.4 Stability Analysis Alternative 3

A stability evaluation was performed for the vegetated spillway, following the guidance of Agricultural Handbook #667, Stability Design of Grass-Lined Open Channels (USDA ARS 1987). The evaluation was performed with a vegetal retardance curve index of 5.6.

Using the 6-hour SDH rainfall value of 13.19 inches, the Alternative 3 auxiliary spillway was evaluated for stability. The evaluation considered fill material classified as CL - lean clay in the steep slope sections and existing alluvium/residuum classified as CH - fat clay in the sections where the slope flattens out. Results for stability analysis for CL and CH soils are in **Table 3.16**.

For the proposed borrowed fill soil type CL, spillway has a topsoil specific gravity of 2.65, plasticity index (PI) of 30, and a dry density of 92 lb/ft$^3$, per **Table 3.11.** The spillway passes the stability criteria with an exit slope of up to of 2.79%. Since Alternative 3 passes the stability criteria, no additional measures need to be taken on the vegetated spillway to prevent loss of vegetation beyond maintain uniform grass coverage. The fat clay (CH) [alluvium/residuum] soil that daylights at the end of the auxiliary spillway was also evaluated. The steeper slope in the lower spillway section after station 16+00 also met stability criteria.

**Table 3.16. Alternative 3 Stability Results**

| STA Range Evaluated | SITES Soil Effective Stress (lb/ft3) | SITES Total Stress (lb/ft3) | SITES Effective Vegetal Stress (lb/ft3) | AH 667 Allowable Soil Stress (lb/ft3) | AH 667 Allowable Vegetal Stress (lb/ft3) | Passes Stability Criteria? (Allowable Stress > Effective Stress) |
|---|---|---|---|---|---|---|
| **Proposed Fill - CL** | | | | | | |
| 1100-1434 | 0.059 | 1.04 | 0.98 | 0.092 | 4.20 | Yes |
| **Alluvium / Residuum - CH** | | | | | | |
| 1434-1610 | 0.050 | 0.88 | 0.83 | 0.163 | 4.20 | Yes |

## 3.5 TCEQ Criteria Evaluation

FRS No. 12 falls under the classification of an intermediate size with a high-hazard potential, requiring it to safely accommodate the design flood hydrograph, expressed as a percentage of the Probable Maximum Flood (PMF). As outlined in TAC 299.15(a)(1)(A), the minimum flood hydrograph is determined through a straight-line interpretation within the specified range (from 75% PMF to full PMF), selecting the greater value between the height of the dam or the maximum storage capacity, whichever yields the highest percentage of the PMF. In the case of Escondido FRS No. 12, the design storm for the existing conditions was estimated at 77% of the PMF (rounded up from 76.23%), based on a peak storage estimate of 3417.7 acre-feet at the effective dam crest elevation.

An average ARC (Type II) curve number of 79.0 was estimated for the uncontrolled contributing Escondido FRS No. 12 subbasin. The Type II curve number (unadjusted) was then converted to a Type III curve number of 89.64 for TCEQ PMF analysis. The same process was done for the six other upstream watersheds to evaluate the TCEQ PMF. The PMP rainfall values were obtained using the TCEQ PMP tool (2017) for storm durations 1 through 72 hours and distributed per the temporal distributions presented in Table 4.2 and Figure 4.1 in *Hydrologic and Hydraulic Guidelines for Dams in Texas* (2007). The evaluation of the existing condition indicates that Escondido FRS No. 12 does not meet the TCEQ requirements and does not safely pass the required 77% of the PMF. The results of the 77% PMF analysis indicate that the 12-hour PMP event results in both the highest spillway peak discharge and the highest reservoir water surface when compared to the other duration storm events, per **Table 3.17**.

The evaluation of Alternative 3 indicates that Escondido FRS No. 12 will meet and exceed the TCEQ requirements. With the proposed new dam height and increased storage, the required PMF event is 76.76%, rounded to 77% PMF for this analysis. Alternative 3 will safely pass the 77% PMF and maintains the 12-hour PMP as the governing event resulting in both the highest spillway peak discharge and the highest reservoir water surface when compared to the other duration storm events. Note that Alternative 3 can also safely pass up to the 100% PMF and maintains the 12-hour PMF as the peak WSE as presented in **Table 3.17**. During final design, the TCEQ governing design storm will be used in development of an updated breach inundation map for Escondido FRS No. 12 for future inclusion in a revised Emergency Action Plan.

**Table 3.17. Escondido FRS No. 12 TCEQ PMF Reservoir Routing Results**

| Storm Duration (hr) | Existing Condition 77% PMF Peak WSE (ft) | Alternative 3 77% PMF Peak WSE (ft) | Alternative 3 100% PMF Peak WSE (ft) |
|---|---|---|---|
| 1 | 339.05 | 339.71 | 340.92 |
| 2 | 342.42 | 342.07 | 343.59 |
| 3 | 342.81 | 342.55 | 343.99 |
| 6 | 342.68 | 342.34 | 343.72 |
| 12 | **343.29** | **343.26** | **344.72** |
| 24 | 342.91 | 342.72 | 343.79 |
| 48 | 341.74 | 341.22 | 341.86 |
| 72 | 340.34 | 340.50 | 340.94 |

The **bolded** value indicates the Escondido FRS No. 12 governing TCEQ design storm result.

# 4. Roadway Damage Estimation

A total of 9 main road segments (main local roads/state highways) and 28 minor road segments (mostly neighborhood roads) were evaluated for flooding downstream of FRS No. 12 near the City of Kenedy and further downstream (**Exhibit D-9**). The evaluation was performed during storm events ranging from a 50% to 0.2% AEP and included roadway surface damage, volume of earth fill damage, and guardrail damage based on the flooding depth and extent. The following criteria were used to apply damage repair and debris removal costs to both public and private roads:

- For all roadways, impacts were considered for water depths exceeding 0.5 feet above the lowest deck elevation.
- For main local roads/state highways (i.e. major roads) inundated by 0.5–1.0 feet that are not Low Water Crossings (LWC), a cost of $3,000 is applied for clearing and/or minor repairs.
- For minor roads parallel to Escondido Creek (i.e. local or neighborhood roads) that are inundated more than 0.5 feet, a $3,000 cost is applied for clearing and/or minor repairs for all storm events (i.e. no damages estimated).
- For the Two identified LWCs, a $3,000 cost is applied for clearing and/or minor repairs for storm events up to and including the 4% AEP. For storm events with a frequency equal to or higher than the 2% AEP, road damages are assumed to occur as described in the first bullet.
- Repair costs include $18.00 per square yard of inundated asphalt (for resurfacing, a 12-inch subbase, and a 2-inch wearing surface), $30.00 per cubic yard for compacted earthfill, and $200.00 per linear foot for impacted guardrail replacement.

Floodwater damage and debris removal assessments were conducted for each alternative and recurrence interval, as detailed in **Table 4-1**. One road segment crossing Doe Branch, eight road segments crossing or running parallel to Escondido Creek (including 28 minor local/neighborhood roads were considered for the economic analysis (refer to **Exhibit D-9**). Two roadways crossing over Escondido Creek were evaluated as LWCs, as they experience overtopping during smaller storm events, such as those with a 50% or 25% AEP. The damages for the 28 minor roads are aggregated and presented as a combined total damage in **Table 4-1.**

## Table 4.1. Road Debris Removal and Repair Cost

| Alternative | Total Cost per Recurrence Interval | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 50% | 20% | 10% | 4% | 2% | 1% | 0.5% | 0.2% |
| **Bucker Creek** | | | | | | | | |
| **Private Access Road** | | | | | | | | |
| Alternative 1 | $ 0 | $ 0 | $ 3,000 | $ 3,000 | $ 3,000 | $ 78,396 | $ 112,886 | $ 148,508 |
| Alternative 2 | $ 3,000 | $ 3,000 | $ 3,000 | $ 3,000 | $ 114,482 | $ 120,503 | $ 144,071 | $ 149,239 |
| Alternative 3 | $ 3,000 | $ 3,000 | $ 3,000 | $ 3,000 | $ 0 | $ 57,947 | $ 113,264 | $ 148,908 |
| **Escondido Creek** | | | | | | | | |
| **US 181** | | | | | | | | |
| Alternative 1 | $ 0 | $ 0 | $ 0 | $ 0 | $ 0 | $ 0 | $ 0 | $ 483,258 |
| Alternative 2 | $ 0 | $ 0 | $ 0 | $ 0 | $ 0 | $ 0 | $ 3,000 | $ 488,962 |
| Alternative 3 | $ 0 | $ 0 | $ 0 | $ 0 | $ 0 | $ 0 | $ 0 | $ 484,422 |
| **N 5th St** | | | | | | | | |
| Alternative 1 | $ 0 | $ 0 | $ 0 | $ 0 | $ 0 | $ 0 | $ 3,000 | $ 3,000 |
| Alternative 2 | $ 0 | $ 0 | $ 0 | $ 0 | $ 225,740 | $ 313,789 | $ 313,789 | $ 313,789 |
| Alternative 3 | $ 0 | $ 0 | $ 0 | $ 0 | $ 0 | $ 0 | $ 3,000 | $ 3,000 |
| **Helena Rd** | | | | | | | | |
| Alternative 1 | $ 0 | $ 0 | $ 0 | $ 0 | $ 0 | $ 0 | $ 170,212 | $ 228,789 |
| Alternative 2 | $ 0 | $ 0 | $ 0 | $ 0 | $ 133,696 | $ 169,720 | $ 207,772 | $ 230,053 |
| Alternative 3 | $ 0 | $ 0 | $ 0 | $ 0 | $ 0 | $ 0 | $ 165,389 | $ 228,893 |
| **CR 331 (LWC)** | | | | | | | | |
| Alternative 1 | $ 3,000 | $ 3,000 | $ 3,000 | $ 3,000 | $ 96,948 | $ 108,749 | $ 115,436 | $ 126,443 |
| Alternative 2 | $ 3,000 | $ 3,000 | $ 3,000 | $ 3,000 | $ 108,246 | $ 114,705 | $ 120,105 | $ 127,369 |
| Alternative 3 | $ 3,000 | $ 3,000 | $ 3,000 | $ 3,000 | $ 97,186 | $ 108,836 | $ 115,003 | $ 126,321 |
| **Private Rd (LWC, Evaluated as public road)** | | | | | | | | |
| Alternative 1 | $ 3,000 | $ 3,000 | $ 3,000 | $ 3,000 | $ 86,793 | $ 159,828 | $ 237,375 | $ 366,590 |
| Alternative 2 | $ 3,000 | $ 3,000 | $ 3,000 | $ 3,000 | $ 141,545 | $ 231,781 | $ 332,825 | $ 367,515 |
| Alternative 3 | $ 3,000 | $ 3,000 | $ 3,000 | $ 3,000 | $ 91,628 | $ 147,937 | $ 233,546 | $ 366,521 |
| **W Main St** | | | | | | | | |
| Alternative 1 | $ 0 | $ 0 | $ 0 | $ 0 | $ 0 | $ 0 | $ 0 | $ 47,667 |
| Alternative 2 | $ 0 | $ 0 | $ 0 | $ 0 | $ 0 | $ 0 | $ 0 | $ 50,426 |
| Alternative 3 | $ 0 | $ 0 | $ 0 | $ 0 | $ 0 | $ 0 | $ 0 | $ 47,964 |
| **SH 72 at Helena Rd** | | | | | | | | |
| Alternative 1 | $ 0 | $ 0 | $ 0 | $ 0 | $ 0 | $ 0 | $ 0 | $ 0 |
| Alternative 2 | $ 0 | $ 0 | $ 0 | $ 0 | $ 0 | $ 0 | $ 0 | $ 3,000 |
| Alternative 3 | $ 0 | $ 0 | $ 0 | $ 0 | $ 0 | $ 0 | $ 0 | $ 0 |
| **SH 72 East** | | | | | | | | |

| Alternative | Total Cost per Recurrence Interval | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 50% | 20% | 10% | 4% | 2% | 1% | 0.5% | 0.2% |
| Alternative 1 | $ 0 | $ 0 | $ 0 | $ 0 | $ 0 | $ 0 | $ 0 | $ 62,621 |
| Alternative 2 | $ 0 | $ 0 | $ 0 | $ 0 | $ 0 | $ 0 | $ 3,000 | $ 65,693 |
| Alternative 3 | $ 0 | $ 0 | $ 0 | $ 0 | $ 0 | $ 0 | $ 0 | $ 62,540 |
| **Minor Roads** | | | | | | | | |
| Alternative 1 | $ 3,000 | $ 3,000 | $ 15,000 | $ 39,000 | $ 63,000 | $ 72,000 | $ 84,000 | $ 84,000 |
| Alternative 2 | $ 3,000 | $ 15,000 | $ 36,000 | $ 66,000 | $ 72,000 | $ 84,000 | $ 84,000 | $ 84,000 |
| Alternative 3 | $ 3,000 | $ 3,000 | $ 21,000 | $ 39,000 | $ 63,000 | $ 72,000 | $ 72,000 | $ 84,000 |

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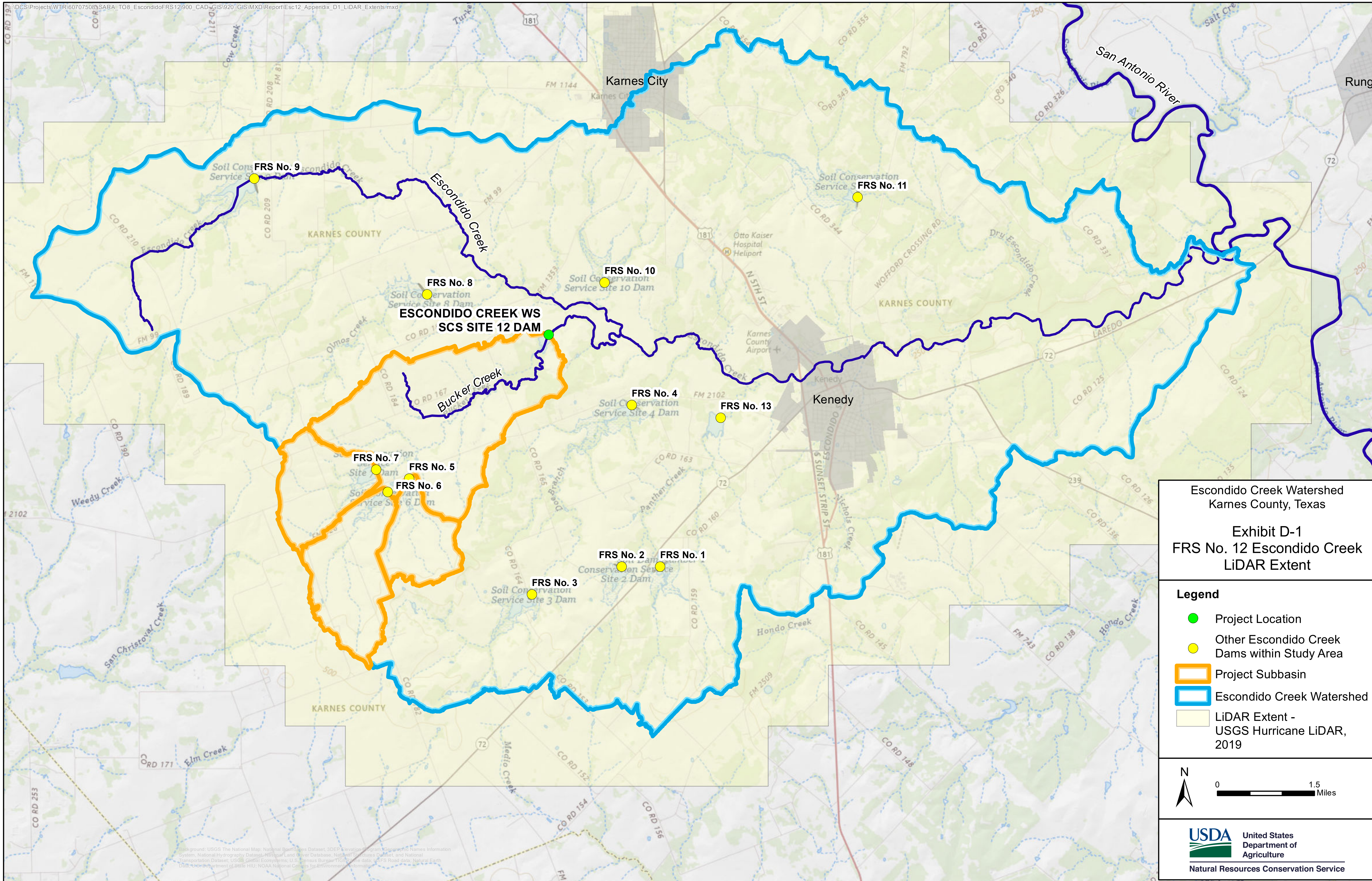
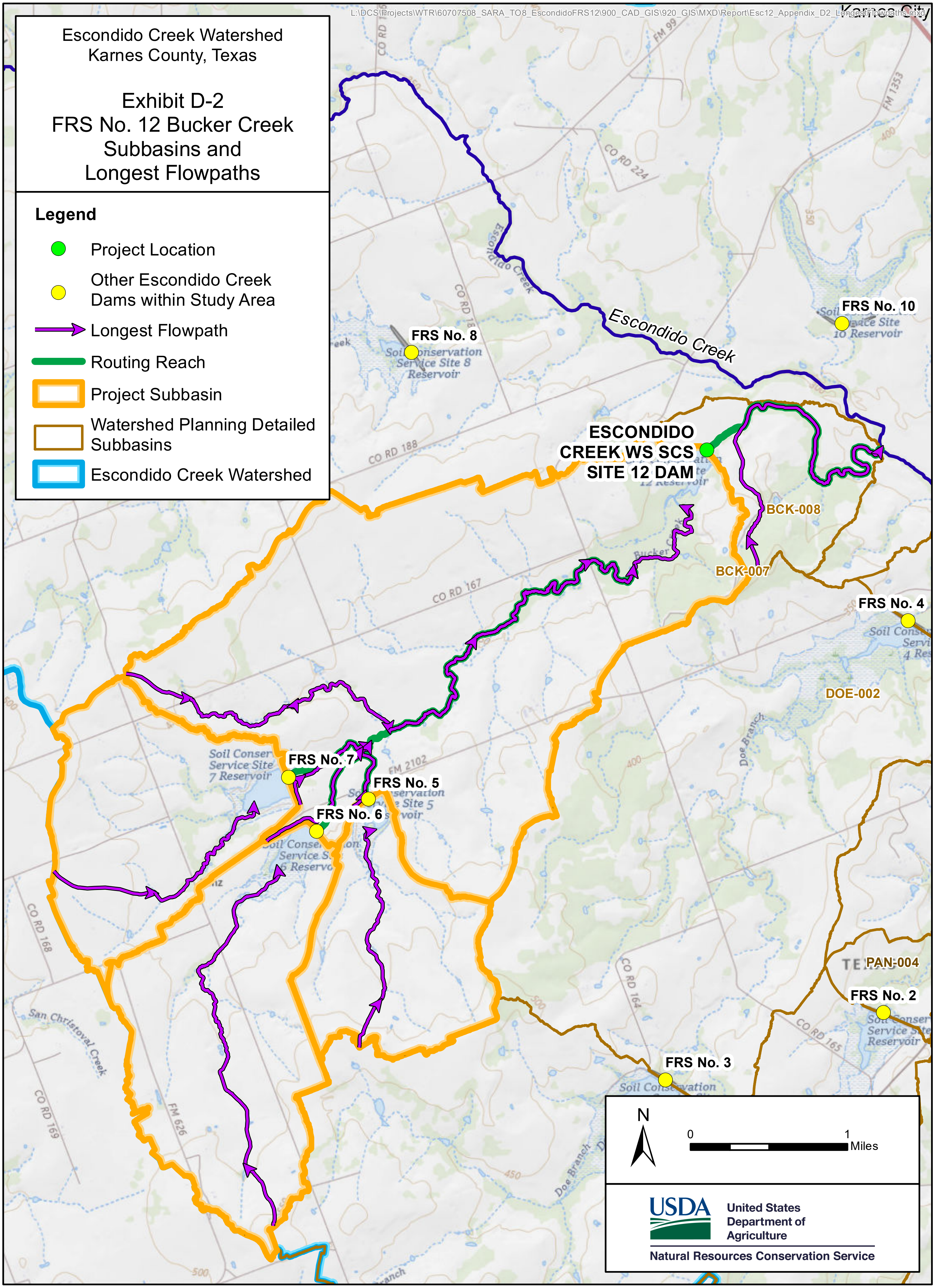
# Figures



Escondido Creek Watershed
Karnes County, Texas
Exhibit D-1
FRS No. 12 Escondido Creek
LiDAR Extent
Legend
Project Location
Other Escondido Creek Dams within Study Area
Project Subbasin
Escondido Creek Watershed
LiDAR Extent - USGS Hurricane LiDAR, 2019
N
0
1.5
Miles
USDA
United States Department of Agriculture
Natural Resources Conservation Service
ESCONDIDO CREEK WS
SCS SITE 12 DAM
FRS No. 1
FRS No. 2
FRS No. 3
FRS No. 4
FRS No. 5
FRS No. 6
FRS No. 7
FRS No. 8
FRS No. 9
FRS No. 10
FRS No. 11
FRS No. 13
Karnes City
Kenedy
Runge
San Antonio River
Escondido Creek
Bucker Creek
KARNES COUNTY



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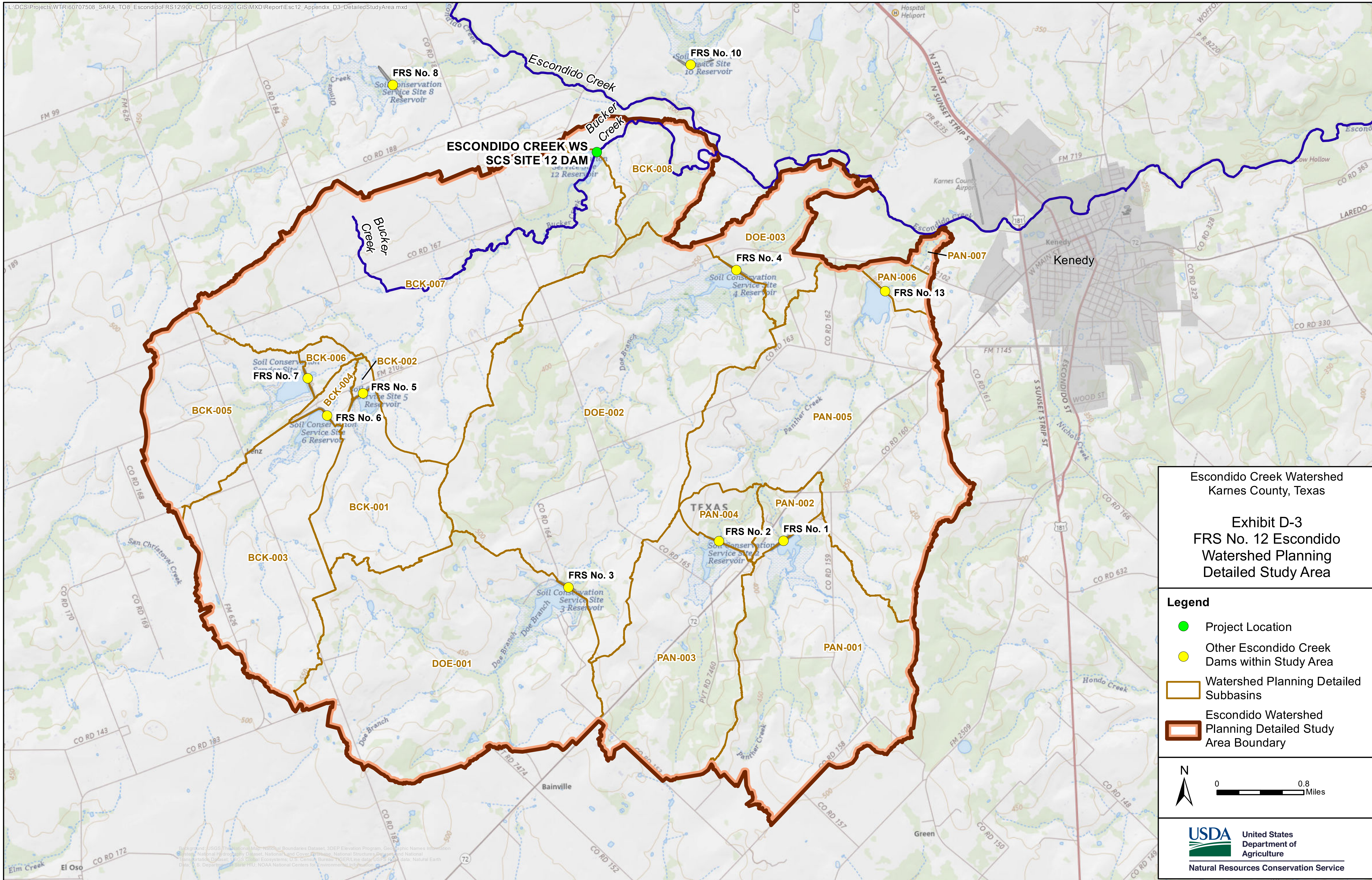
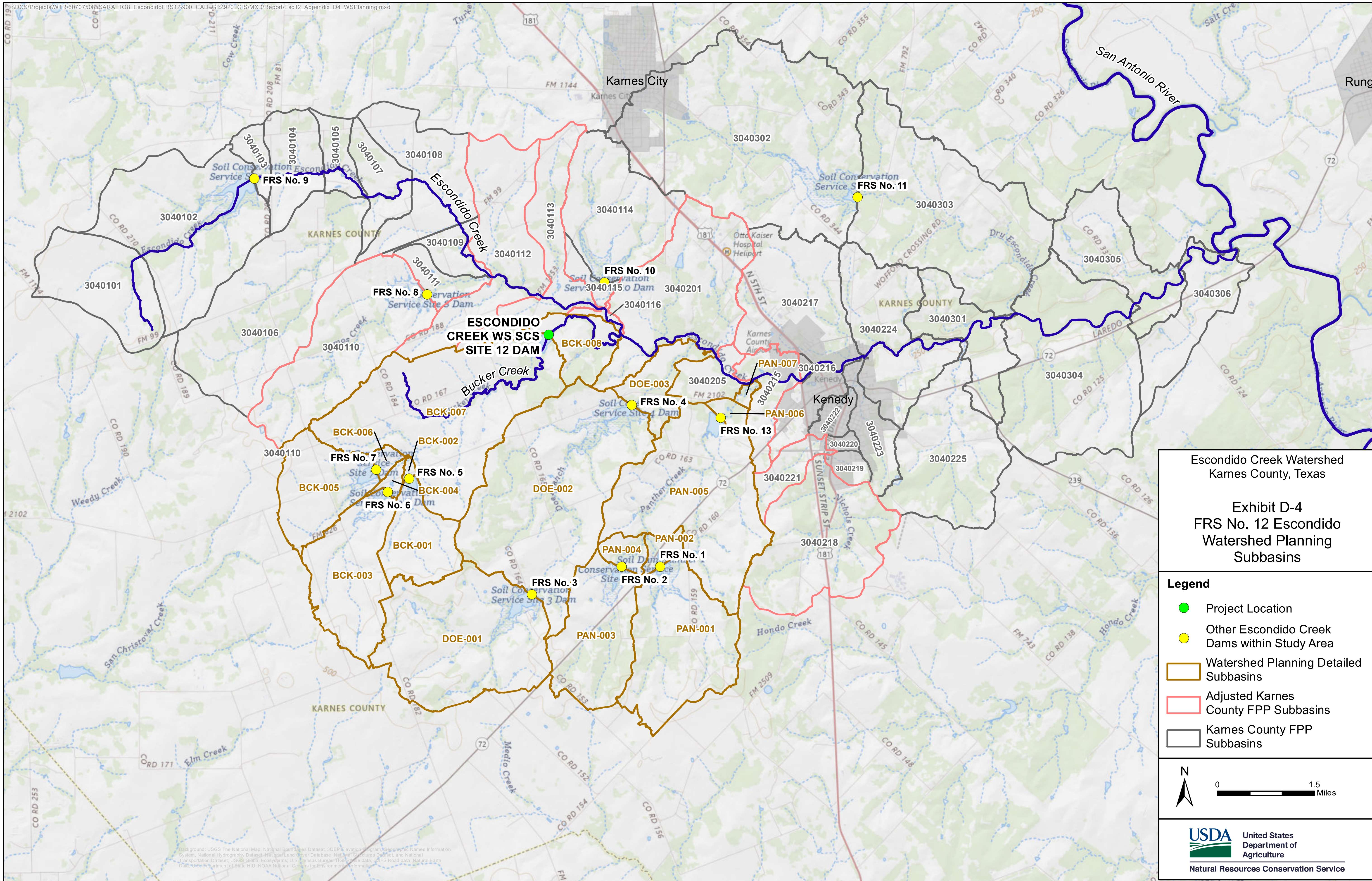
Escondido Creek Watershed
Karnes County, Texas
Exhibit D-2
FRS No. 12 Bucker Creek
Subbasins and
Longest Flowpaths
Legend
Project Location
Other Escondido Creek Dams within Study Area
Longest Flowpath
Routing Reach
Project Subbasin
Watershed Planning Detailed Subbasins
Escondido Creek Watershed
Escondido Creek
ESCONDIDO CREEK WS SCS SITE 12 DAM
FRS No. 8
FRS No. 10
FRS No. 4
FRS No. 7
FRS No. 5
FRS No. 6
FRS No. 2
FRS No. 3
BCK-008
BCK-007
DOE-002
PAN-004
CO RD 188
CO RD 167
CO RD 224
CO RD 168
CO RD 169
CO RD 164
CO RD 165
FM 2102
FM 626
FM 99
FM 1353
San Christoval Creek
Doe Branch
N
0
1
Miles
USDA
United States Department of Agriculture
Natural Resources Conservation Service


Escondido Creek Watershed
Karnes County, Texas
Exhibit D-3
FRS No. 12 Escondido
Watershed Planning
Detailed Study Area
Legend
Project Location
Other Escondido Creek Dams within Study Area
Watershed Planning Detailed Subbasins
Escondido Watershed Planning Detailed Study Area Boundary
N
0
0.8
Miles
USDA
United States Department of Agriculture
Natural Resources Conservation Service
ESCONDIDO CREEK WS SCS SITE 12 DAM
FRS No. 1
FRS No. 2
FRS No. 3
FRS No. 4
FRS No. 5
FRS No. 6
FRS No. 7
FRS No. 8
FRS No. 10
FRS No. 13
BCK-001
BCK-002
BCK-003
BCK-004
BCK-005
BCK-006
BCK-007
BCK-008
DOE-001
DOE-002
DOE-003
PAN-001
PAN-002
PAN-003
PAN-004
PAN-005
PAN-006
PAN-007
Escondido Creek
Bucker Creek
Kenedy
Bainville
Green
El Oso


Escondido Creek Watershed
Karnes County, Texas
Exhibit D-4
FRS No. 12 Escondido
Watershed Planning
Subbasins
Legend
Project Location
Other Escondido Creek
Dams within Study Area
Watershed Planning Detailed
Subbasins
Adjusted Karnes
County FPP Subbasins
Karnes County FPP
Subbasins
N
0
1.5
Miles
USDA
United States
Department of
Agriculture
Natural Resources Conservation Service
ESCONDIDO
CREEK WS SCS
SITE 12 DAM
FRS No. 1
FRS No. 2
FRS No. 3
FRS No. 4
FRS No. 5
FRS No. 6
FRS No. 7
FRS No. 8
FRS No. 9
FRS No. 10
FRS No. 11
FRS No. 13
BCK-001
BCK-002
BCK-003
BCK-004
BCK-005
BCK-006
BCK-007
BCK-008
DOE-001
DOE-002
DOE-003
PAN-001
PAN-002
PAN-003
PAN-004
PAN-005
PAN-006
PAN-007
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3040223
3040224
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3040301
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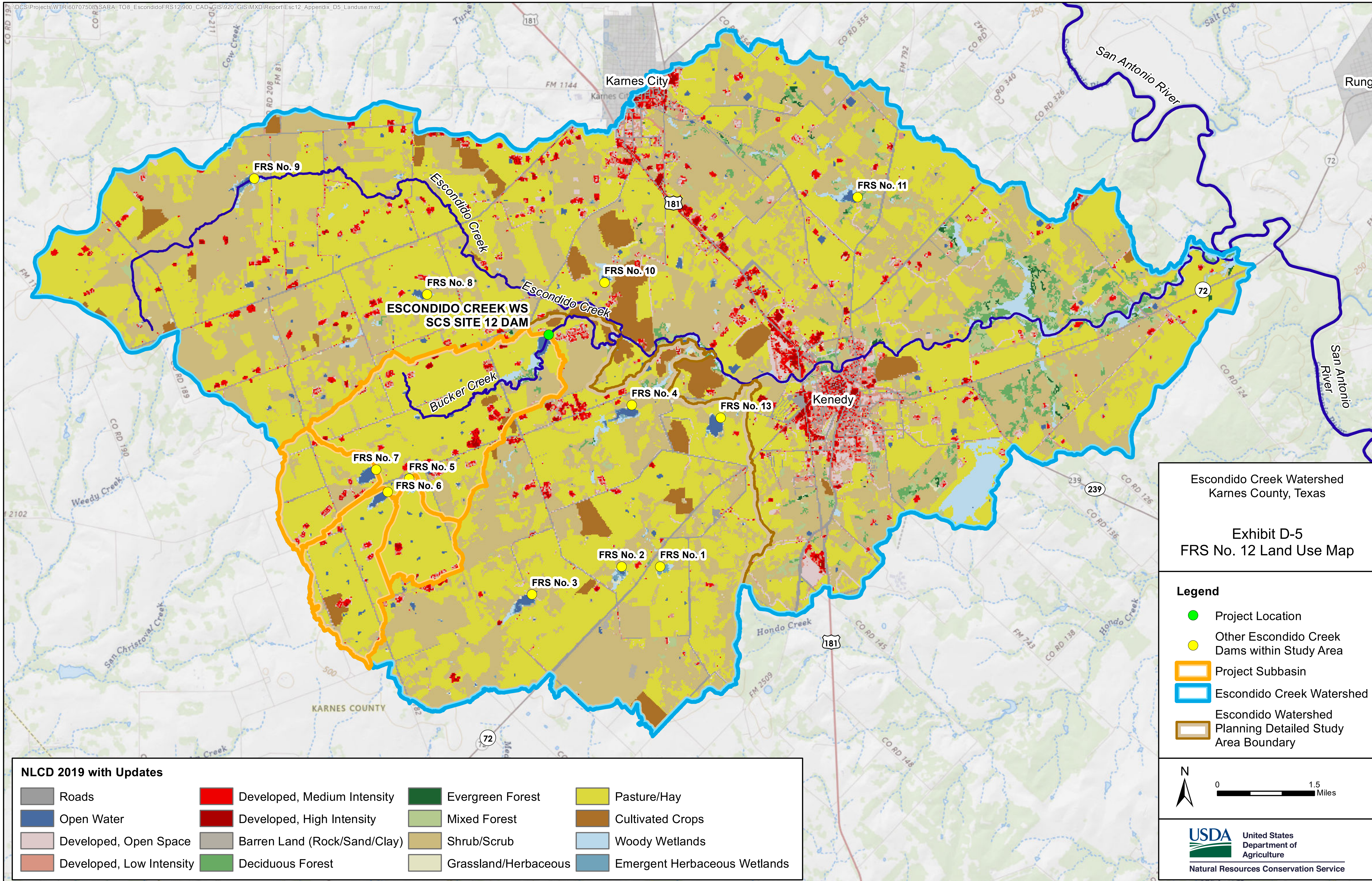
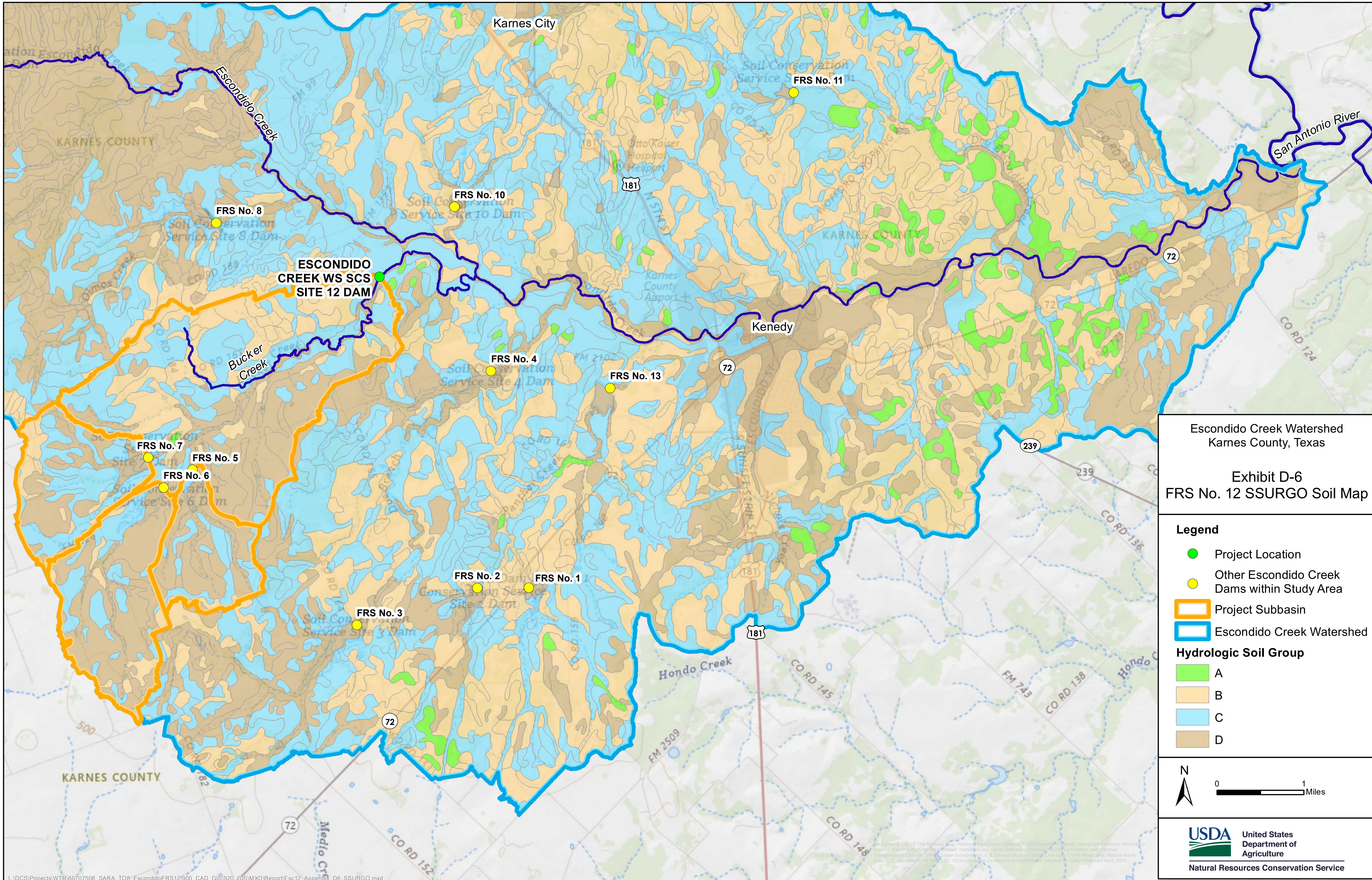
Karnes City
Kenedy
Runge
San Antonio River
Escondido Creek
Bucker Creek
KARNES COUNTY



Karnes City
Runge
San Antonio River
Escondido Creek
Bucker Creek
Kenedy
FRS No. 9
FRS No. 8
FRS No. 10
FRS No. 11
FRS No. 4
FRS No. 13
FRS No. 7
FRS No. 5
FRS No. 6
FRS No. 2
FRS No. 1
FRS No. 3
ESCONDIDO CREEK WS
SCS SITE 12 DAM
Hondo Creek
KARNES COUNTY
Weedy Creek
San Christoval Creek
Escondido Creek Watershed
Karnes County, Texas
Exhibit D-5
FRS No. 12 Land Use Map
Legend
Project Location
Other Escondido Creek Dams within Study Area
Project Subbasin
Escondido Creek Watershed
Escondido Watershed Planning Detailed Study Area Boundary
N
0
1.5
Miles
USDA
United States Department of Agriculture
Natural Resources Conservation Service
NLCD 2019 with Updates
Roads
Open Water
Developed, Open Space
Developed, Low Intensity
Developed, Medium Intensity
Developed, High Intensity
Barren Land (Rock/Sand/Clay)
Deciduous Forest
Evergreen Forest
Mixed Forest
Shrub/Scrub
Grassland/Herbaceous
Pasture/Hay
Cultivated Crops
Woody Wetlands
Emergent Herbaceous Wetlands



Escondido Creek Watershed
Karnes County, Texas
Exhibit D-6
FRS No. 12 SSURGO Soil Map
Legend
Project Location
Other Escondido Creek Dams within Study Area
Project Subbasin
Escondido Creek Watershed
Hydrologic Soil Group
A
B
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Miles
USDA
United States Department of Agriculture
Natural Resources Conservation Service
ESCONDIDO CREEK WS SCS SITE 12 DAM
FRS No. 1
FRS No. 2
FRS No. 3
FRS No. 4
FRS No. 5
FRS No. 6
FRS No. 7
FRS No. 8
FRS No. 10
FRS No. 11
FRS No. 13
Karnes City
Kenedy
Escondido Creek
Bucker Creek
San Antonio River
Hondo Creek
KARNES COUNTY
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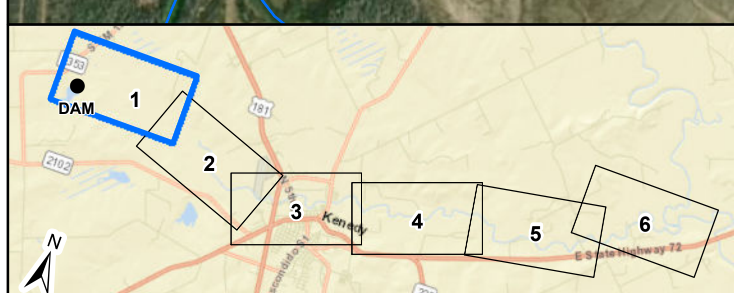



N

0 600 Feet

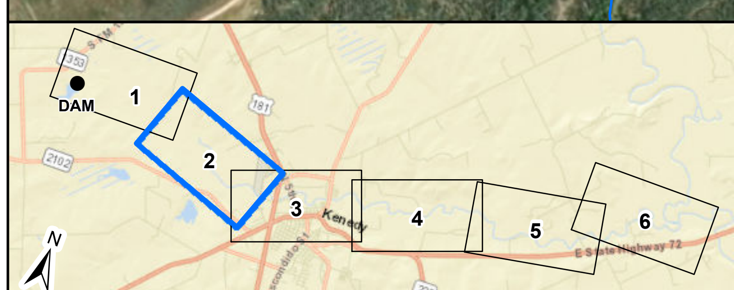
**Legend**

- Escondido Creek HEC-RAS Cross-Sections
- Bucker Creek HEC-RAS Cross-Sections

USDA United States Department of Agriculture
Natural Resources Conservation Service

Escondido Creek Watershed
Karnes County, Texas

Exhibit D-7
FRS No. 12 HEC-RAS
Cross-Section Map
1 of 6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0 600 Feet

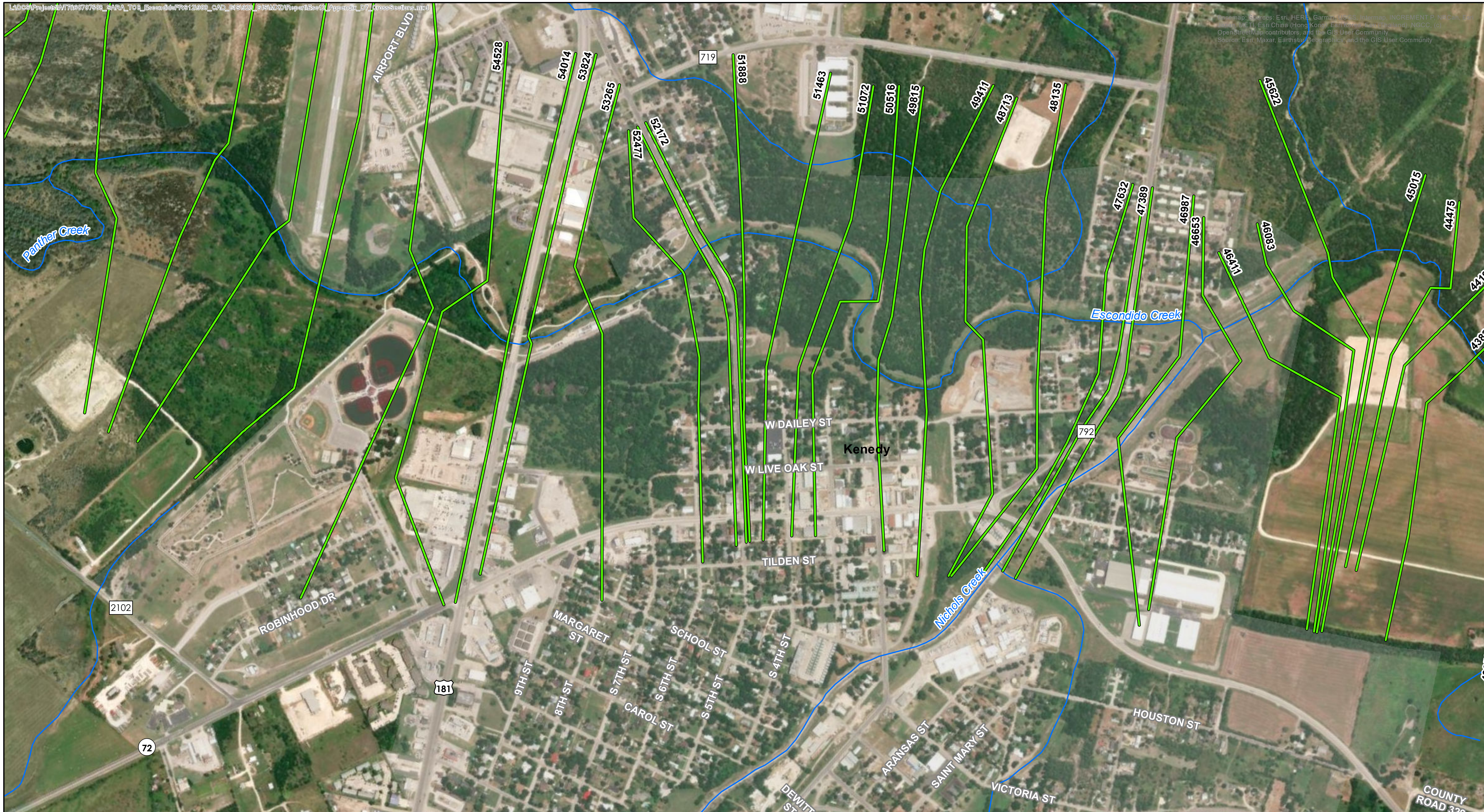
USDA United States Department of Agriculture
Natural Resources Conservation Service

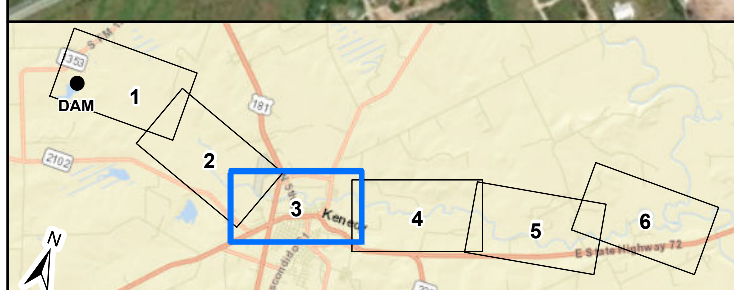
**Legend**

- Escondido Creek HEC-RAS Cross-Sections
- Bucker Creek HEC-RAS Cross-Sections

Escondido Creek Watershed
Karnes County, Texas

Exhibit D-7
FRS No. 12 HEC-RAS
Cross-Section Map
2 of 6

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0 600 Feet

USDA United States Department of Agriculture

Natural Resources Conservation Service

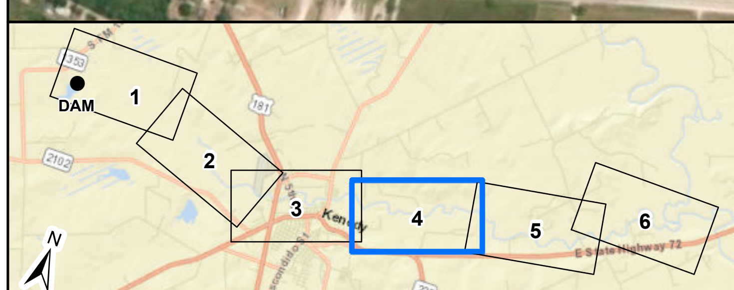
**Legend**

Escondido Creek HEC-RAS Cross-Sections

Bucker Creek HEC-RAS Cross-Sections

Escondido Creek Watershed
Karnes County, Texas

Exhibit D-7
FRS No. 12 HEC-RAS
Cross-Section Map
3 of 6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United States Department of Agriculture

Natural Resources Conservation Service

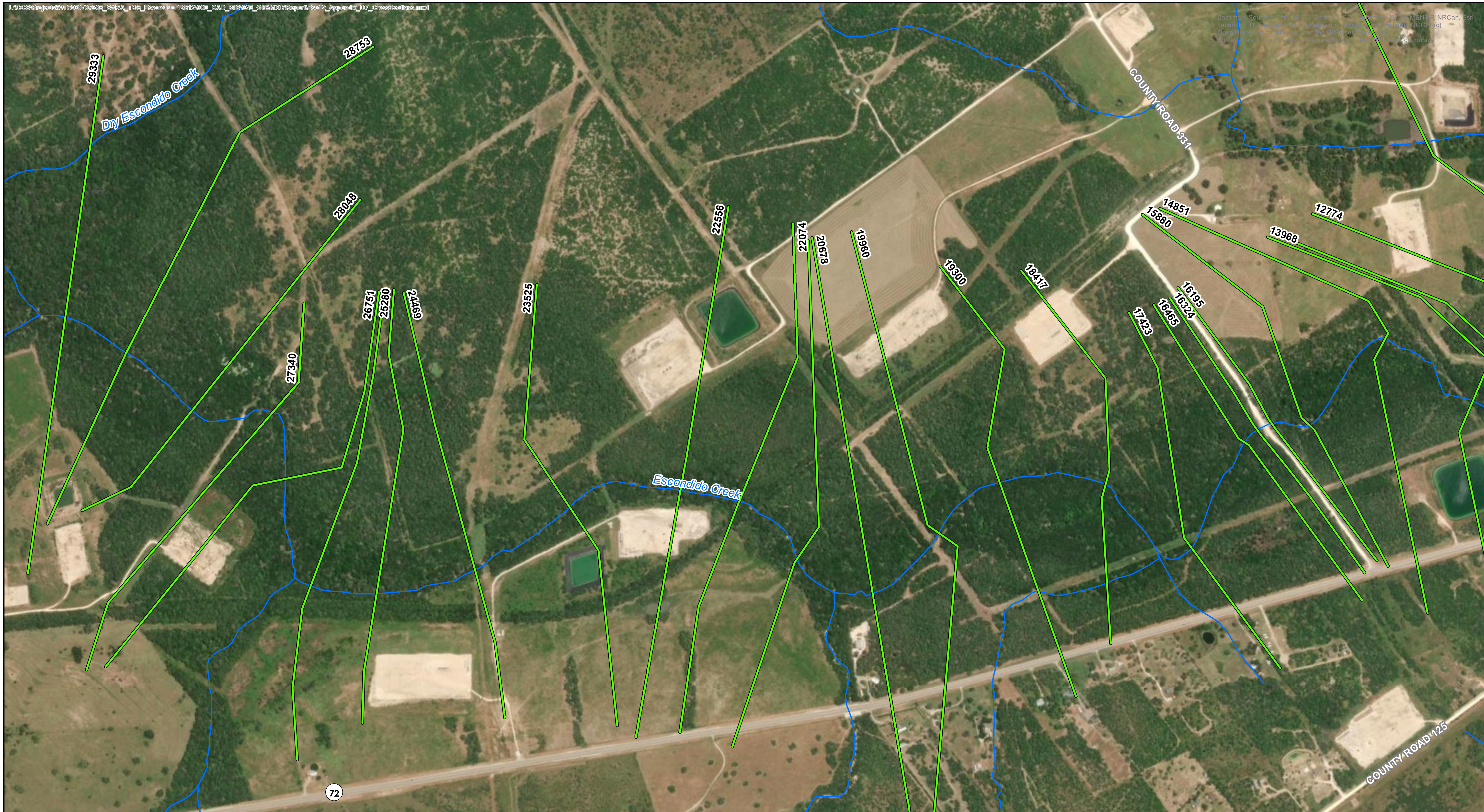
**Legend**

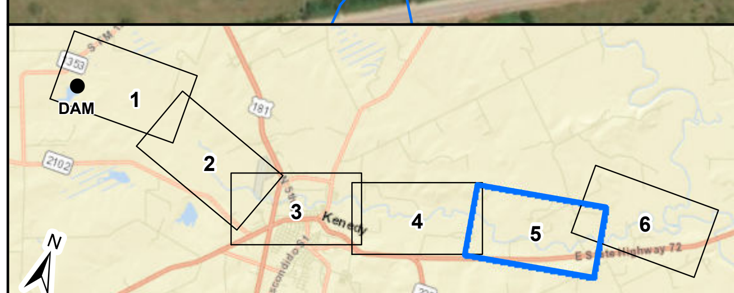
Escondido Creek HEC-RAS Cross-Sections

Bucker Creek HEC-RAS Cross-Sections

Escondido Creek Watershed
Karnes County, Texas

Exhibit D-7
FRS No. 12 HEC-RAS
Cross-Section Map
4 of 6




N

0 600 Feet

**Legend**

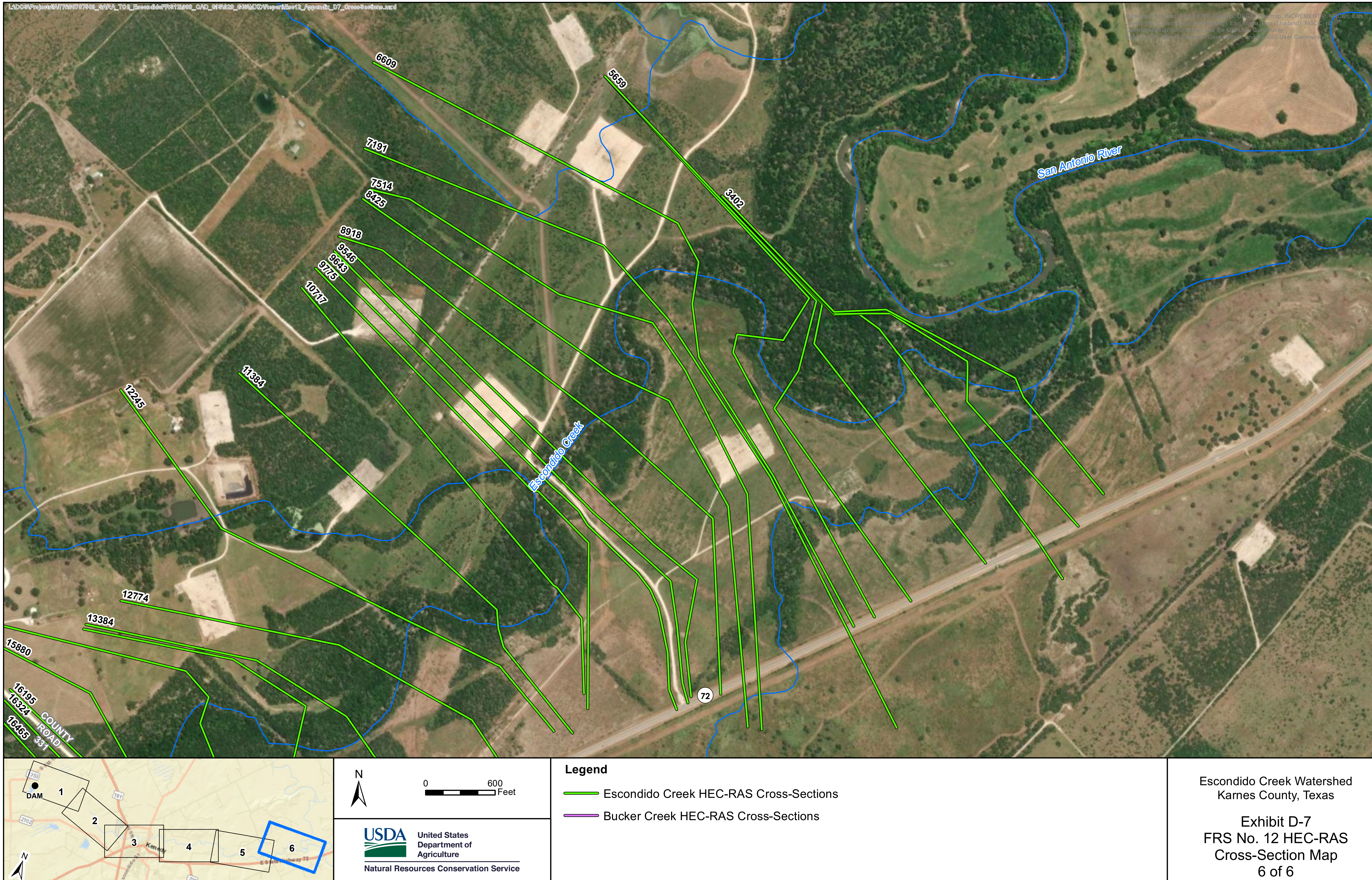
Escondido Creek HEC-RAS Cross-Sections

Bucker Creek HEC-RAS Cross-Sections

USDA United States Department of Agriculture
Natural Resources Conservation Service

Escondido Creek Watershed
Karnes County, Texas

Exhibit D-7
FRS No. 12 HEC-RAS
Cross-Section Map
5 of 6




**Legend**

Escondido Creek HEC-RAS Cross-Sections

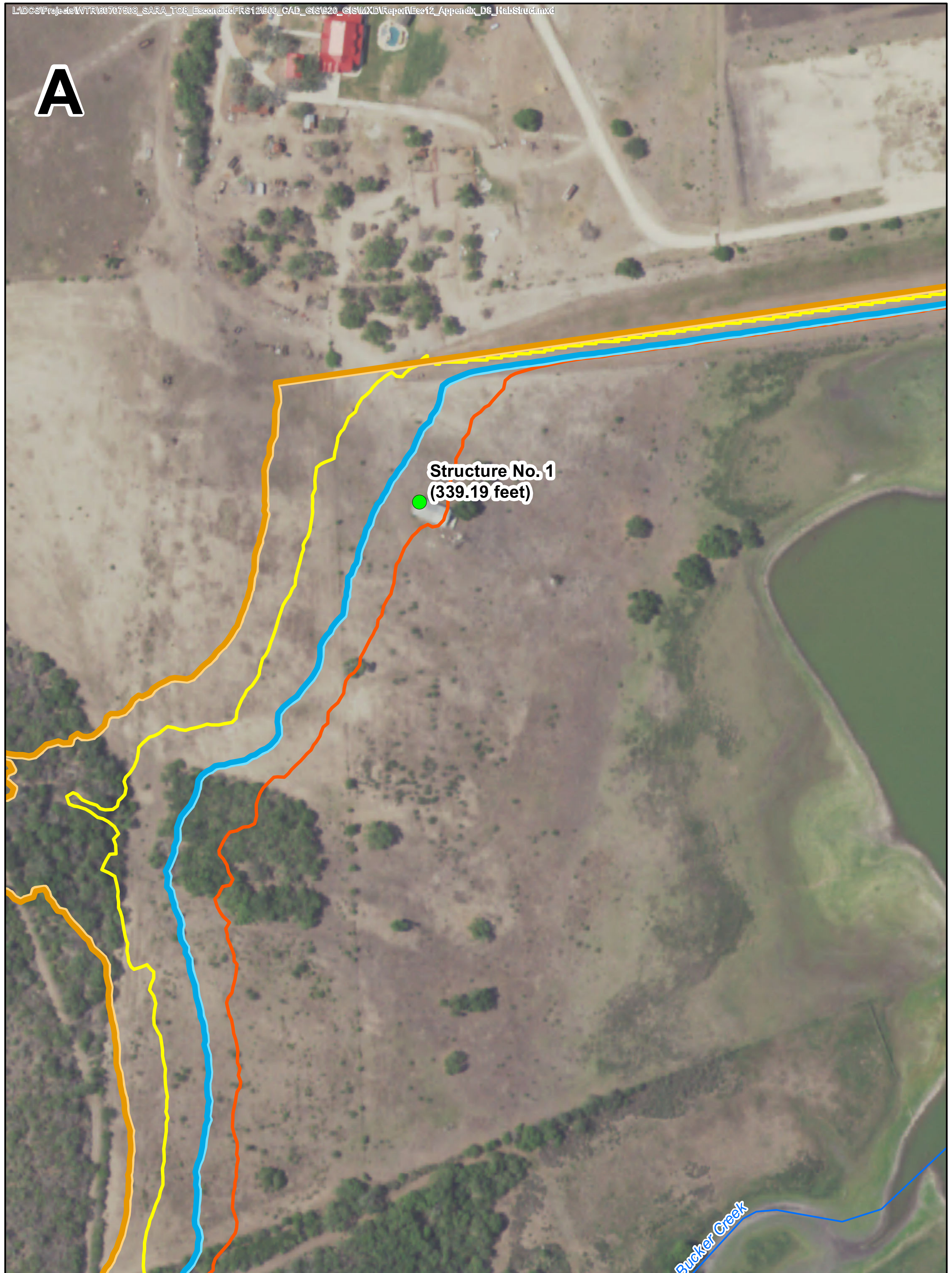
Bucker Creek HEC-RAS Cross-Sections

USDA United States Department of Agriculture

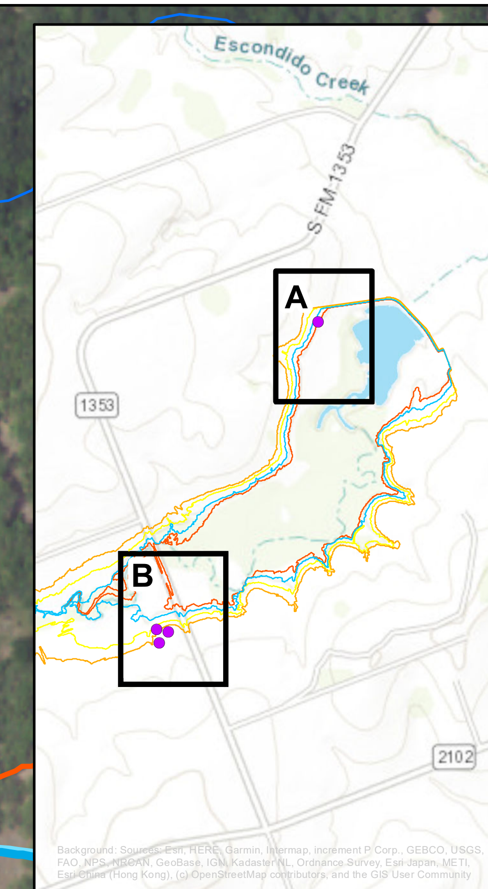
Natural Resources Conservation Service

Escondido Creek Watershed
Karnes County, Texas

Exhibit D-7
FRS No. 12 HEC-RAS
Cross-Section Map
6 of 6








Escondido Creek Watershed
Karnes County, Texas

Exhibit D-8
FRS No. 12
Backwater Habitable
Structures Map

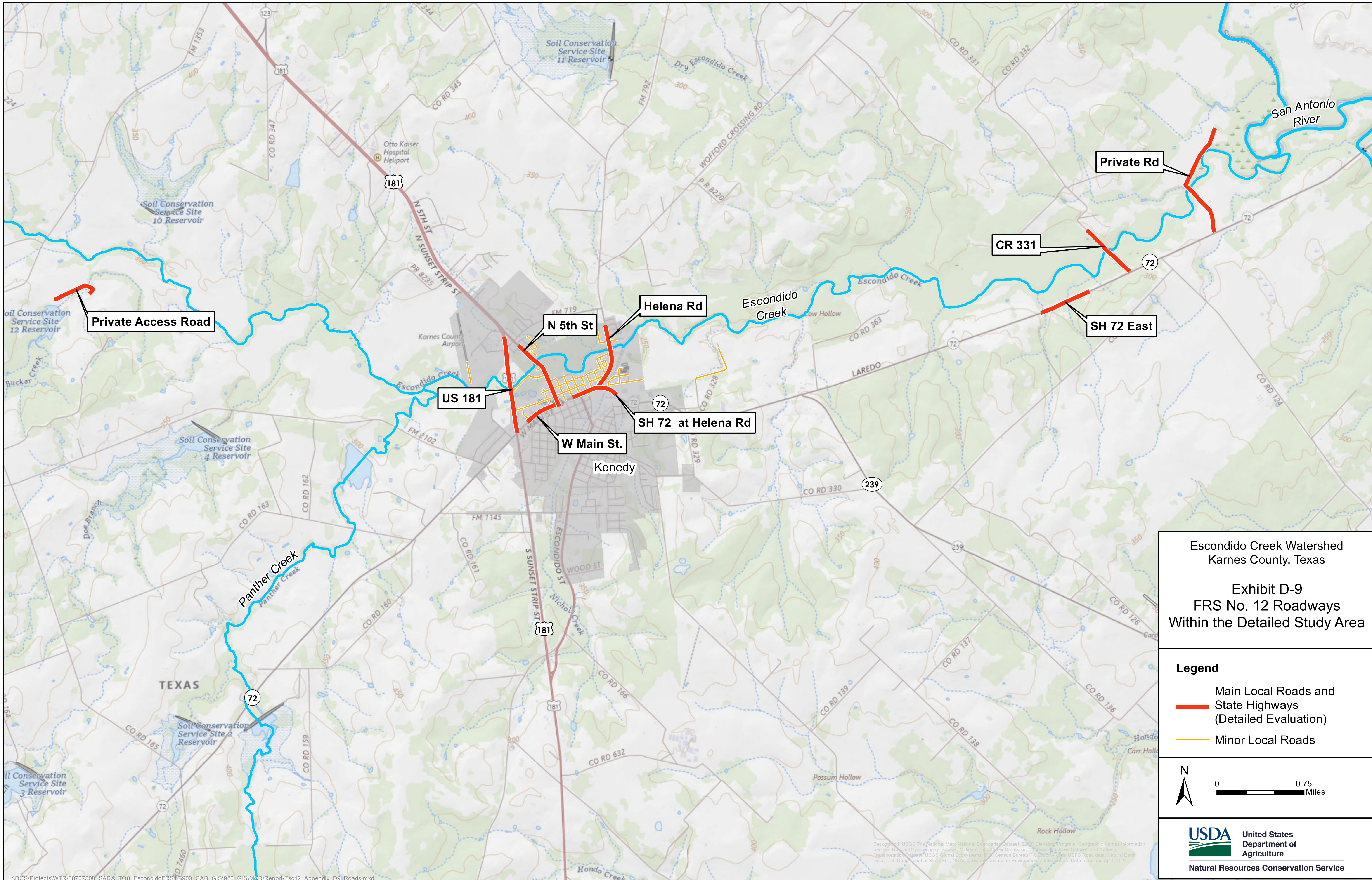
**Legend**

- Surveyed First Floor Elevation
- Estimated First Floor Elevation
- As-Built Auxiliary Spillway (336.13 feet)
- Alternative 3 Auxiliary Spillway (338.70 feet)
- As-Built Top of Dam (342.23 feet)
- Alternative 3 Top of Dam (345.30 feet)
- Stream

N

0 200 Feet

USDA United States Department of Agriculture
Natural Resources Conservation Service

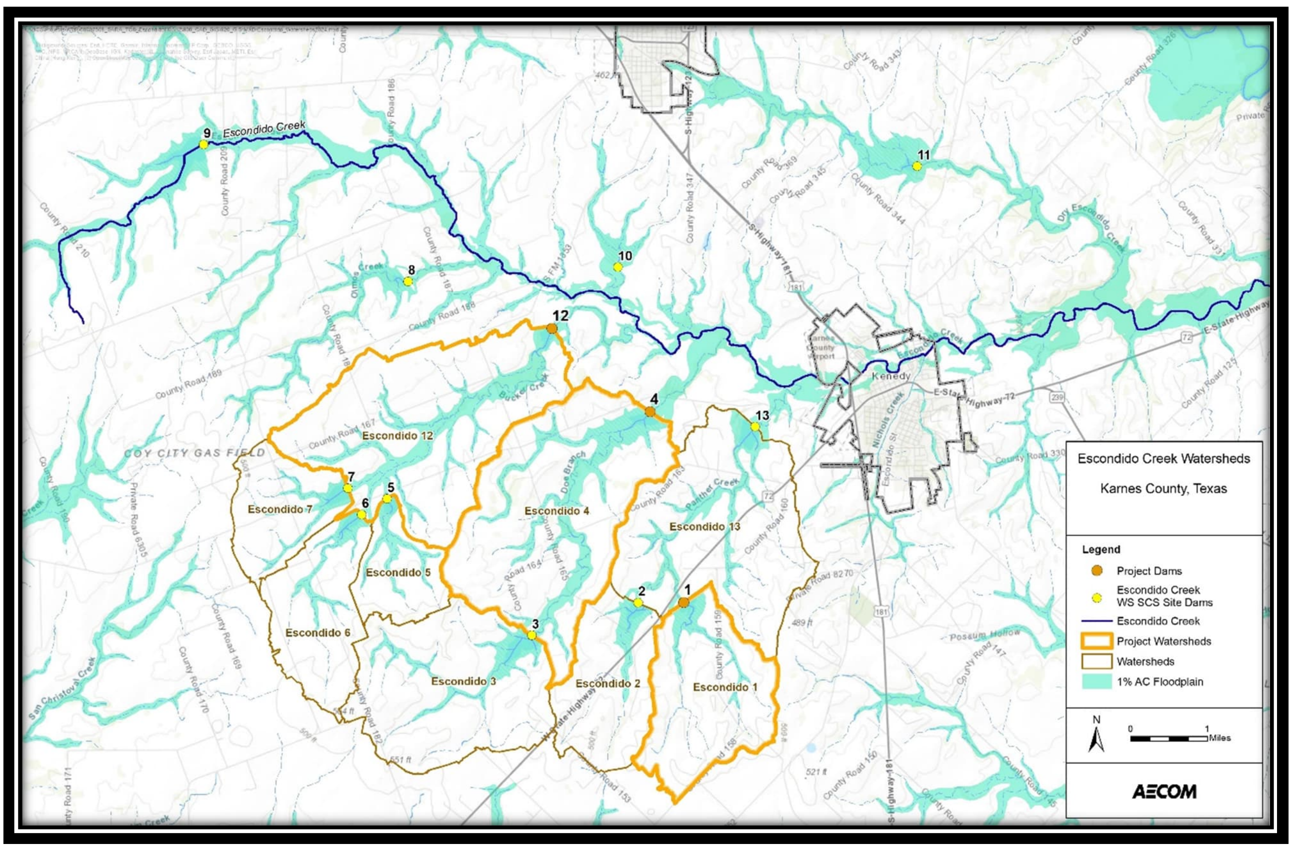

Escondido Creek Watershed
Karnes County, Texas
Exhibit D-9
FRS No. 12 Roadways
Within the Detailed Study Area
Legend
Main Local Roads and State Highways (Detailed Evaluation)
Minor Local Roads
N
0
0.75
Miles
USDA
United States Department of Agriculture
Natural Resources Conservation Service
Private Access Road
N 5th St
Helena Rd
US 181
W Main St.
SH 72 at Helena Rd
Kenedy
CR 331
Private Rd
SH 72 East
San Antonio River
Escondido Creek
Panther Creek
TEXAS

**Technical Memorandum – Economic Analysis**
**Supplemental Watershed Plan and Environmental Document for Escondido FRS No. 12 Supplemental Watershed Plan**

## D.1 INTRODUCTION

Economic analyses were conducted for the flood risk management alternatives associated with the Escondido Supplemental Watershed Plan for Flood Retarding Structure (FRS) No.12 (the "Project") and Environmental Document. The United States Department of Agriculture, Natural Resources Conservation Service (NRCS), and Karnes County Soil and Water Conservation District, Escondido Watershed District, San Antonio River Authority, and the City of Kenedy as the Project sponsors. The Project is located in Karnes County, Texas with the downtown city of Kenedy located to the east. Figure 1 displays the study area, where Dam 12 is on Bucker Creek which feeds into the mainstem of Escondido Creek. The NRCS proposes to partially fund the Project through the Watershed Protection and Flood Prevention Act (Public Law [PL] 83-566).

**Figure 1 Study Area**




Following a preliminary analysis of possible alternatives, three alternatives were carried forward for evaluation. The alternatives are comprised of a No Federal Action (future-without-project [FWOP]) alternative and two future-with-federal-investment (FWFI) alternatives, one of which is federal decommissioning of the dam and the other involves high hazard potential rehabilitation (HHPR). **Table 1** describes the alternatives evaluated for the Project.

**Table 1. Description of Project Alternatives**

| Alternative | Description |
|---|---|
| Alternative 1. No Federal Action (FWOP) | Continue regular maintenance of the existing system. No modifications would be made to address concerns (i.e., existing conditions would remain). It is assumed that the dam will eventually fail and not be subsequently rebuilt or rehabilitated. |
| Alternative 2. Federal Decommissioning (FWFI) | Controlled breach of the dam. |
| Alternative 3. HHPR (FWFI) | Dam would be rehabilitated to meet both federal and state design standards. Add new 42” conduit and riser with PS crest 325.1 ft. Raise existing vegetated auxiliary spillway crest and install 180 ft wide labyrinth weir with five cycle and stilling basin. Extend cutoff trench below extended embankment. Top of dam raise of about 3.1 ft. |

# D.2 ECONOMIC FRAMEWORK

In general, the national economic benefits and costs presented in this supplemental plan were developed based on guidance contained in the *Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies*[1]. Guidance specific to defining the No Federal Action (FWOP) was sourced from the NRCS’s *Title 309 – National Instruction, Part 303 – Clarification and Instructions for the No-Action Alternative in Supplemental Watershed Rehabilitation Plans.*[2]

Economic feasibility for a FWFI alternative is determined by comparing the average annual benefits to the average annual costs. The economic analysis considers the No Federal Action alternative as the baseline condition, which assumes the existing conditions with no major changes made to the floodplain. The analysis is formulated from the perspective that changes/impacts resulting from implementation of a FWFI alternative in relation to the No Federal Action alternative were measured as a cost or a benefit (i.e., a zero benefit, zero cost approach was applied to No Federal Action alternative). Costs and benefits are reported in 2024 dollars (2024$) and were evaluated over a 103-year period of analysis (36 months of construction[3] and 100-year evaluation period/design life). The costs and benefits were annualized over the 100-year evaluation period using a 2.75 percent discount rate. Inputs or assumptions provided in a year prior to 2024 were adjusted to 2024 dollars using the U.S. Gross Domestic Product (GDP) deflators.

The hydrologic and hydraulic (H&H) analysis conducted for each of the alternatives was used to estimate the depth of flooding throughout the study area. The economic analysis uses inundation models for eight flood recurrence intervals, which are the 50-percent- (2-year), 20-precent- (5-year), 10-percent- (10-year), 4-percent- (25-year), 2-percent- (50-year), 1-percent- (100-year), 0.5-percent- (200-year), and 0.2-percent- (500-year) flood event, to estimate future damages from flooding within the study area.

Under the No Federal Action alternative, the dam would not be brought up to current federal or state standards and many of the underlying issues would remain. Therefore, there is a chance for the dam to fail from a seismic, hydraulic, or static event. A static failure was estimated to have the highest probability of

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[1] U.S. Water Resources Council, 1983. *Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies,* March 1983.

[2] USDA Natural Resource Conservation Service, 2022. *Title 309 – National Instruction, Part 303 – Clarification and Instructions for the No-Action Alternative in Supplemental Watershed Rehabilitation Plans,* December 2022.

[3] During the period of construction, a cofferdam will be put in place to control flows for the duration of the construction period, providing continued flood protection through the 1-percent flood event.

occurring. Since a spillway integrity failure does not occur before the static failure, these two failure options were not evaluated as a joint probability or union of events. As a result, a one-time static failure with a probability of 0.04 percent (2,255-year event) for FRS No. 12 was evaluated as part of the No Federal Action alternative.

## D.3 BENEFIT ANALYSIS

The following describes the analyses used to evaluate the benefits of the FWFI alternatives. The benefits represent damage/cost reduction from future flooding and are evaluated in average annual terms. The benefit categories evaluated were:

- Residential and nonresidential structures
- Automobiles
- Debris removal
- Road damages
- Agriculture

### D.3.1 Residential and Nonresidential Structures

Knowledge of existing development located in a floodplain is essential when evaluating a flood risk management measure. An inventory was conducted of residential and nonresidential structures located in the study area, which serves as the base data for the economic analysis. The structure inventory comprises residential and nonresidential structures located within the maximum flood extent for the combined sunny day breach inundation zone plus the 500-year decommission scenario with a 200-foot buffer. Data from the Karnes County Assessor was obtained, cleaned, and used as the basis for the structure inventory. Detailed descriptions of the data cleaning process can be found in Appendix A. A total of 220 properties were identified based on the data cleaning process performed in GIS.

The structures were assigned a building class and structure type based on the structure descriptions in the Assessor data. **Table 2** lists assigned depth-damage functions, structure types, and number of structures in the inventory. Additionally, the improvement value (excludes land value) listed in the Assessor database was used as a proxy for the depreciated replacement value of the structure.

**Table 2. Structure Types in Study Area**

| Building Class | Structure Type | Number of Structures |
|---|---|---|
| Fast Food | Non-residential | 1 |
| Grocery | Non-residential | 1 |
| Hotel | Non-residential | 1 |
| Industrial Light | Non-residential | 12 |
| Medical Office | Non-residential | 1 |
| Mobile Home | Residential – No Basement | 43 |
| Non-Fast Food | Non-residential | 2 |
| Office One-Story | Non-residential | 2 |
| Recreation | Non-residential | 2 |
| Religious Facilities | Non-residential | 8 |
| Residential-2NB (2 story, No Basement) | Residential – No Basement | 4 |
| Residential-NB (No Basement) | Residential – No Basement | 119 |
| Retail-Clothing | Non-residential | 1 |
| Retail-Electronics | Non-residential | 8 |
| Warehouse – Non-Refrigerated | Non-residential | 15 |
| | **Total** | **220** |

The economic analysis was conducted using the USACE, Hydrologic Engineering Center – Flood Damage Reduction Analysis (HEC-FDA)[4] software. H&H data for Escondido and Bucker Creek were uploaded into the software and contained river stations and the water surface elevation at each recurrence interval for each of the alternatives. Each structure was assigned to the closest river station using GIS and was formatted and uploaded into HEC-FDA. Each structure was assigned a depth-damage function (DDF) based on the building class. To estimate the depth of inundation in relation to the FFE of each structure, the foundation height was factored into its mean elevation. Structures were assigned a foundation height (height of FFE above the ground) based on the structure type as seen in **Table 3**. The total damages from each recurrence interval were annualized by HEC-FDA to estimate the average annual damages for each alternative. HEC-FDA uses Monte Carlo simulation as part of its risk analysis and is reflected in the final output of the results. This accounts for a level of uncertainty in the economic analysis.

**Table 3: Assumed Foundation Heights**

| Structure Type | Foundation Height (Feet Above Ground Level) |
|---|---|
| Nonresidential | 0.5 |
| Residential – No Basement | 0.5 |
| Mobile Home | 2.5 |

[4] Flood Damage Reduction Analysis (HEC-FDA). https://www.hec.usace.army.mil/software/hec-fda/

### D.3.2 Automobiles

The damages to automobiles were determined using the USACE EGM 09-04, *Generic Depth-Damage Relationships for Vehicles*.[5] In accordance with the guidance, the elevation of each automobile was assumed to be the mean ground elevation estimated at each structure. The damages to vehicles at residences depends on the following: the average number of vehicles per household and the percentage of vehicles that are likely to be at the residence at the time the flood waters reach the property.

In 2021, the median number of vehicles per household in Karnes County, Texas was two.[6] The average vehicle value was obtained from Consumer Reports[7]. The average retail value for used vehicles was $28,000 in 2024.

The length of potential warning time and the access to a safe evacuation route to a flood-free location were considered to estimate the percentage of vehicles that would likely remain in the flood-prone location. For Karnes County, the analysis assumes that the warning time would be less than 6 hours; therefore, 50.5 percent of the vehicles in the flood area would be evacuated according to USACE EGM 09-04 and 49.5 percent would remain.

Because only those vehicles not used for evacuation can be included in the damage calculations, an adjusted average vehicle value of $28,000 ($28,000 x 2 x 0.495) was assigned to each individual residential structure. The analysis calculated automobile damages for each flood recurrence interval. No automobiles were assigned to nonresidential structures.

### D.3.3 Debris Removal

When flooding occurs, debris can accumulate from flood damage, requiring efforts to bring debris to the street for pickup and removal. The DDFs incorporated into HEC-FDA do not include this cost, therefore debris removal costs were conducted manually using Excel. The costs associated with debris removal were estimated based on guidance from the Federal Emergency Management Agency (FEMA) and were grouped with structure damages for the purposes of this analysis.

Debris removal costs were estimated for every residential structure that incurred flooding above the FFE. The debris costs per structure include the hauling cost, tipping fee, and labor to remove debris and break it into pieces that could be hauled to the street for pickup.

FEMA has estimated there are 25 to 30 cubic yards of debris for a flooded residential structure without a basement and 45 to 50 cubic yards for a residential structure with a basement. The cost to load and haul away debris was estimated using the average cost per cubic yard of $38 from the Homewyse Debris Removal Cost Calculator (October 2023). The FEMA Debris Estimation Field Guide conversion factor of 4 cubic yards of debris per ton was used to convert the total debris removal cost per cubic yard to debris removal cost per ton. In addition, the disposal cost of $20 per ton was included; resultantly, a debris removal cost of $170 per ton was incorporated into the analysis.

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[5] USACE, 2009. *Generic Depth-Damage Relationships for Vehicles*, EGM 09-04. June 22. https://planning.erdc.dren.mil/toolbox/guidance.cfm?Option=BL&BL=OnlyInlandFlood&Type=None&Sort=Default.

[6] Data USA, 2021. *Karnes County, TX.* https://datausa.io/profile/geo/karnes-county-tx

[7] *Consumer Reports, 2023. Used Care Prices Remain High, Making Buying a Challenge.* https://www.consumerreports.org/cars/buying-a-car/when-to-buy-a-used-car-a6584238157/#:~:text=Currently%2C%20the%20average%20price%20of,not%20everyone%20has%20that%20luxury.

Using the Homewyse Debris Removal Cost Calculator (October 2023), the number of labor hours to break down debris and move it from the structure to the street was estimated to be 1.4 hours for every cubic yard of debris. Because homeowners are forgoing other activities to clean up debris, including work and leisure, the opportunity cost was applied to value this time. The value of time was estimated using the 2022 median household income for Karnes County from the Census (adjusted to 2024 dollars) and dividing by 2,080 hours to get $29.83, representing the hourly opportunity cost of work per household. For leisure time, an opportunity cost of $19.90 was assigned based on the common practice used in economics literature to value recreation time as a fraction of the wage. In literature, this fraction ranges from one-third the wage to the full wage; therefore, a fraction of two-thirds was used to estimate the opportunity cost of leisure. During the flood aftermath, owners were assumed to forego recreation two-thirds of the time and forego work one-third of the time, for an average opportunity cost of time of $23.26 per hour. **Table 4** presents the average cost of debris removal from a flooded residential structure without a basement.

**Table 4. Summary of Residential Debris Costs – Structure with No Basement**

| Structure Description | Cubic Yards of Debris | Debris Removal Labor and Disposal Costs | Owner Opportunity Cost of Time | Total Debris Cost |
|---|---|---|---|---|
| Without Basement | 25 to 30 | $1,178 | $896 | $2,074 |

Note: 2024 price level

### D.3.4 Road Damages

Modelling was completed to estimate the expected road damages for each of the alternatives during the eight flood recurrence intervals. Ten roads were evaluated for damages due to flooding in the study area. **Table 5** presents the road damages by alternative and recurrence intervals.

**Table 5. Summary of Road Damages**

| Alt. | 2-year | 5-year | 10-year | 25-year | 50-year | 100-year | 200-year | 500-year | Average Annual Damages |
|---|---|---|---|---|---|---|---|---|---|
| **Alt 1** | $9,000 | $9,000 | $24,000 | $48,000 | $220,000 | $422,000 | $723,000 | $1,900,000 | $20,000 |
| **Alt 2** | $12,000 | $24,000 | $45,000 | $301,000 | $884,000 | $1,034,000 | $1,209,000 | $1,921,000 | $51,000 |
| **Alt 3** | $12,000 | $12,000 | $30,000 | $48,000 | $252,000 | $390,000 | $702,000 | $1,902,000 | $21,000 |

Note: 2024 price level. All values are rounded to the nearest thousand.

### D.3.5 Agriculture

Knowledge of existing agricultural land located in a floodplain is essential when evaluating flood risk management measures. Part of the analysis includes estimating the benefits of the FWFI alternatives based on a reduction in agricultural damages. Agricultural impacts assessed include economic losses due to crop damages. The analysis is based on the timing, duration, and extent of flooding. This section describes the methods used to estimate agricultural damages for each alternative.

## Flood Impacts

Flood damage to crops can result in replanting, fertilizing, additional spraying, and reduced crop yields. A flood occurring prior to the start of field preparation may cause damages (e.g., reduced yields) from delay of seeding. However, due to uncertainty, these damages were not captured in the model. Following a damaging flood that occurs near the beginning of the growing season, a farmer would likely rework the land and replant the same or a substitute crop to minimize loss. Variable production costs for a replanted crop are usually higher than those without a flood because additional fertilizer must be applied to offset loss of soil fertility. Herbicides are often required to combat weed infestation, and additional preparation of seed beds is required.

Crop loss functions were obtained and used to calculate the weighted average damage per acre of flooded agricultural land. Current normalized prices were used to counteract the frequent short-term fluctuations of crop prices. Total crop damages per acre amount to the difference between the expected net income without a flood and the net income with a flood, accounting for crop damage and additional planting and production costs.

## Crops in Study Area

Agricultural Census data was reviewed for the study area in GIS to identify crops grown and their percent of total impacted agricultural land. **Table 6** identifies the crops grown in the study area and the crop distribution.

**Table 6. Crops in Study Area**

| Crop | Percent of Acreage |
|---|---|
| Forage | 20.5% |
| Corn | 18.2% |
| Sorghum | 8.3% |
| Cotton | 53.0% |

## Crops Progress for Texas Crops

The extent of crop damages from flooding is dependent on the point in the growing season in which a flood occurs. Following a flood that occurs near the beginning of the growing season, it is assumed that a farmer would rework the land and replant the same or a substitute crop to minimize loss. Total crop damages per acre amount to the difference between the expected net income without a flood and the net income with a flood, accounting for crop damage and additional planting and production costs.

Information from the U.S. Department of Agriculture (USDA) was obtained to determine the months in which crops are planted and harvested.[8]

[8] USDA, *Field Crops Usual Planting and Harvest Dates, October 2010.* Retrieved https://www.nass.usda.gov/Publications/Todays_Reports/reports/fcdate10.pdf

## Crop Damage Analysis

The crop progress for Texas crops were used to extract crop DDFs from the USACE, Hydrologic Engineering Center – Flood Impact Analysis software (HEC-FIA). Necessary inputs to obtain loss functions include first plant date, full yield date, last planting date, and end of harvest date. **Table 7** provides definitions for each input, as defined in the *HEC-FIA User's Manual* Version 2.2, and the respective assumption used in the analysis.[9]

**Table 7. HEC-FIA Crop Assumptions**

| Date/Days | HEC-FIA Definition | Assumption |
|---|---|---|
| First Plant Date | First date that the crop can be planted. | First day of the earliest month in which crops were planted in Texas. |
| Full Yield Date | Latest date that the crop can be planted and still reach full maturity. | One month prior to the Last Planting date. |
| Last Planting Date | Latest date that the crop can be planted with a reduction in yield. | Last day of latest month in which crops were planted in Texas. |
| End of Harvest Date | Last date that the crop is harvested, after which little damage can be incurred. | Last day of final month in which crops are harvested. |
| Dryout Period (days) | Number of days after a flood has receded before the soil is sufficiently dry so replanting can begin. FIA automatically adds 7 days on to the dryout period to allow for re-cultivation of the fields. | The default value in HEC-FIA. Default includes a period of 3 days for dryout and 7 days for recultivation for a 10-day period following inundation before crops can be replanted. |

The data on crop progress was used to make the crop planting and harvesting date assumptions shown in **Table 8**, which were then used to extract the appropriate DDFs from HEC-FIA.

**Table 8. Crop Plant Data Assumptions**

| Crop | First Plant Date | Full Yield Date | Last Planting Date | End of Harvest Date |
|---|---|---|---|---|
| Forage | 1-May | 15-May | 1-Jun | 25-Sep |
| Corn | 1-Mar | 7-Apr | 17-May | 8-Nov |
| Sorghum | 1-Mar | 1-May | 5-Jul | 6-Dec |
| Cotton | 22-Mar | 7-May | 20-Jun | 11-Jan |

The HEC-FIA loss functions estimate "Initial % Crop Loss" values, which represents an estimate of the percentage of the mature crop value that is expected to be damaged if the crop was planted on the First Plant Date. Initial % Crop Loss values depend on the date in which a flood event occurs, and factors crop plant data into its estimates. HEC-FIA also categorizes crop damages as a percent of crop yield for flood

[9] USACE, 2012. *HEC-FIA User's Manual, Version 2.2*, September. https://www.hec.usace.army.mil/software/hec-fia/documentation/HEC-FIA_22_Users_Manual.pdf.

events lasting 0, 3, 7, and 14 days, based on the vulnerability of the crop to flood damage. Straight line interpolation was used to estimate total crop damages as a percent of crop yield for flood events lasting 1 to 2 days.

**Tables 9 and 10** provide the crop damage assumptions for 1 to 2 days of inundation.

**Table 9. Crop Damages from 1 Day Inundation**

| Crop | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Forage | 12% | 13% | 16% | 18% | 20% | 24% | 29% | 32% | 21% | 10% | 10% | 11% |
| Corn | 0% | 0% | 0% | 4% | 13% | 22% | 25% | 27% | 32% | 24% | 10% | 1% |
| Sorghum | 0% | 0% | 0% | 4% | 13% | 22% | 25% | 27% | 32% | 24% | 10% | 1% |
| Cotton | 7% | 7% | 8% | 8% | 11% | 17% | 20% | 20% | 21% | 20% | 10% | 10% |

**Table 10. Crop Damages from 2 Days Inundation**

| Crop | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Forage | 25% | 27% | 31% | 36% | 40% | 47% | 57% | 64% | 42% | 19% | 19% | 22% |
| Corn | 0% | 0% | 0% | 8% | 27% | 44% | 50% | 55% | 64% | 48% | 20% | 2% |
| Sorghum | 0% | 0% | 0% | 8% | 27% | 44% | 50% | 55% | 64% | 48% | 20% | 2% |
| Cotton | 14% | 15% | 16% | 16% | 21% | 35% | 40% | 41% | 43% | 40% | 20% | 20% |

## Crop Planting and Production Prices

To monetize crop damages, the analysis estimated planting costs and production costs for each of the crops, estimated by acre, using data on budgets by commodity sourced from USDA and UC Davis Cooperative Extension Sample Costs to Produce. Additional planting costs per acre were seed, equipment operating expenses, and crop insurance. Additional production costs were herbicides, fertilizer, fungicide, and insecticide. **Table 11** lists estimates for crop replanting and production costs per acre for primary crops in the study area.

**Table 11. Planting and Production Costs per Acre**

| Item | Crop | | | |
|---|---|---|---|---|
| | Forage | Corn | Sorghum | Cotton |
| **Replanting Costs (per acre)** | $170 | $249 | $87 | $353 |
| **Production Costs (per acre)** | $221 | $412 | $412 | $601 |

Values listed in **Table 11** were used to estimate replanting costs per acre following a flood event. The analysis assumes replanting would occur following any flood event that occurred in a month in which the damaged crop could be replanted (i.e., before the last plant date). Acres replanted were assumed to equal acres damaged in the flood event.

## Crop Production Value

To complete the assessment of agricultural flood damages, production values of each crop per acre were estimated by multiplying the average yield by the normalized price per unit. Yields per acre were obtained from USDA National Agricultural Statistics Service.[10]

Normalized prices for all crops were also sourced from USDA National Agricultural Statistics Service. **Table 12** displays the average crop yield and average production value per acre for all crops in the analysis.

**Table 12. Average Crop Yield and Average Production Value**

| Item | Crop | | | |
|---|---|---|---|---|
| | **Forage** | **Corn** | **Sorghum** | **Cotton** |
| Average Yield (unit/acre) | 2 tons | 95 bushels | 53 bushels | 734 lbs |
| Normalized Prices (per unit) | $198 | $8 | $5 | $1 |
| Average Production Value per Acre | $339 | $747 | $264 | $811 |

Sources: USDA

## Likelihood of Flooding by Month

To determine the likelihood of a flood occurring each month, the probability that a storm event would occur in a month was estimated from monthly precipitation data for Karnes County between 1990 and 2022 from the National Oceanic and Atmospheric Administration's (NOAA's) National Center for Environmental Information. Average monthly precipitation values were divided by the total average annual precipitation to calculate the percentage of precipitation that occurs each month. The percentage of precipitation per month was used as a proxy for the likelihood of a storm event occurring, as displayed in **Table 13**.

**Table 13. Likelihood of Flooding by Month**

| Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 2.1% | 1.8% | 2.7% | 2.9% | 4.5% | 3.8% | 3.5% | 2.8% | 4.4% | 3.4% | 2.5% | 2.2% |

Source: NOAA National Centers for Environmental information, Climate at a Glance: County Time Series, retrieved October 2023 from https://www.ncdc.noaa.gov/cag/

## Agricultural Benefits

An Excel based model was developed to estimate the average annual agricultural damages for the No Federal Action and FWFI alternatives. The model incorporates the factors presented above and the H&H data that estimates the agricultural acres flooded by duration of either 24 or 48 hours for six flood recurrence intervals (0.2%, 0.5%, 1%, 2%, 4% and 10%).

[10] USDA National Agricultural Statistics Service – Quick Stats. https://quickstats.nass.usda.gov/

A summary of agricultural benefits by project alternative is provided in **Table 14**.

**Table 14. Summary of Agricultural Benefits**

| Alternative | Annual Damages | Annual Benefits |
|---|---|---|
| Alternative 1- No Federal Action | $4,000 | $0 |
| Alternative 2 – Federal Decommission | $7,000 | -$3,000 |
| Alternative 3 - HHPR | $4,000 | $0 |

Notes: 2024 price level, all values rounded to the nearest thousand

### D.3.6 Benefit Summary

This section summarizes the benefits analysis, which includes comparisons of the impacts to structures from the alternatives. Structure-related benefits include damage reductions to structures, contents, automobiles, and debris removal. A summary of damages for all alternatives by recurrence interval is provided in **Table 15.**

**Table 15. Summary of Damages by Recurrence Interval (2024$)**

| Recurrence Interval | | Building & Autos | Contents | Road Damages | Debris Removal | Total Damages |
|---|---|---|---|---|---|---|
| **Alternative 1 – No Action** | | | | | | |
| 50% | 2-year | $1,000 | $1,000 | $9,000 | $0 | $11,000 |
| 20% | 5-year | $15,000 | $8,000 | $9,000 | $2,000 | $34,000 |
| 10% | 10-year | $68,000 | $26,000 | $24,000 | $2,000 | $120,000 |
| 4% | 25-year | $426,000 | $190,000 | $48,000 | $17,000 | $681,000 |
| 2% | 50-year | $1,091,000 | $435,000 | $250,000 | $62,000 | $1,838,000 |
| 1% | 100-year | $1,857,000 | $682,000 | $422,000 | $116,000 | $3,077,000 |
| 0.5% | 200-year | $3,283,000 | $1,177,000 | $723,000 | $180,000 | $5,363,000 |
| 0.2% | 500-year | $7,024,000 | $2,794,000 | $1,900,000 | $265,000 | $11,983,000 |
| | | | | | | |
| Breach, 0.04% | 2,255-year | $4,458,000 | | | | |
| Average Annual Damages | | $194,000 | | | | |
| **Alternative 2 – Federal Decommission** | | | | | | |
| 50% | 2-year | $5,000 | $4,000 | $12,000 | $0 | $21,000 |
| | | | | | | |
| 20% | 5-year | $65,000 | $25,000 | $24,000 | $2,000 | $116,000 |
| 10% | 10-year | $248,000 | $116,000 | $45,000 | $6,000 | $415,000 |
| 4% | 25-year | $1,568,000 | $593,000 | $301,000 | $93,000 | $2,555,000 |
| 2% | 50-year | $3,024,000 | $1,164,000 | $884,000 | $164,000 | $5,236,000 |
| 1% | 100-year | $3,882,000 | $1,481,000 | $1,034,000 | $199,000 | $6,596,000 |
| 0.5% | 200-year | $4,926,000 | $1,920,000 | $1,209,000 | $226,000 | $8,281,000 |
| 0.2% | 500-year | $7,196,000 | $2,876,000 | $1,921,000 | $270,000 | $12,263,000 |
| Average Annual Damages | | $401,000 | | | | |
| **Alternative 3 - HHPR** | | | | | | |
| 50% | 2-year | $1,000 | $1,000 | $12,000 | $0 | $14,000 |
| 20% | 5-year | $17,000 | $8,000 | $12,000 | $2,000 | $39,000 |
| 10% | 10-year | $80,000 | $33,000 | $30,000 | $2,000 | $145,000 |
| 4% | 25-year | $473,000 | $207,000 | $48,000 | $19,000 | $747,000 |
| 2% | 50-year | $1,145,000 | $452,000 | $252,000 | $64,000 | $1,913,000 |
| 1% | 100-year | $1,915,000 | $703,000 | $390,000 | $118,000 | $3,126,000 |
| 0.5% | 200-year | $2,971,000 | $1,062,000 | $702,000 | $164,000 | $4,899,000 |
| 0.2% | 500-year | $7,053,000 | $2,809,000 | $1,902,000 | $265,000 | $12,029,000 |
| Average Annual Damages | | $199,000 | | | | |

Notes: 2024 price level; Average Annual Damages includes risk and uncertainty; all values rounded to the nearest thousand and therefore may have addition discrepancies

The following summarizes the total annual average benefits quantified for each project alternative. To estimate the average annual damages associated with each alternative, the total damages were averaged between each recurrence interval and applied to the incremental probability between the respective flood events. The benefits for each FWFI alternative were estimated by comparing the damages that would occur under the alternative with those that would occur under the No Action alternative. The benefits were evaluated over the 100-year period of evaluation. A summary of total average annual damages avoided is provided in **Table 16.**

**Table 16. Summary of Total Average Annual Damages Avoided (2024$)**

| Alternative | Total Average Annual Structural Damages | Total Average Annual Agriculture Damages | Total Average Annual Road Damages | Total Average Annual Damages | Total Average Annual Damages Avoided |
|---|---|---|---|---|---|
| Alt 1 – No Action | $174,000 | $4,000 | $20,000 | $198,000 | $0 |
| Alt 2 – Federal Decommission | $350,000 | $7,000 | $51,000 | $408,000 | -$210,000 |
| Alt 3 – HHPR | $178,000 | $4,000 | $21,000 | $203,000 | -$5,000 |

Note: all values rounded to the nearest thousand and therefore may have addition discrepancies.

## D.4 COST ANALYSIS

The average annual operation and maintenance (O&M) costs for each alternative were estimated. The net O&M costs for each FWFI alternative is the difference between the cost for the No Action alternative and the FWFI alternative (**Table 17**).

**Table 17. Annual Operation and Maintenance Costs (2024$)**

| Alternative | Annual O&M Costs | Net Annual O&M Costs |
|---|---|---|
| Alternative 1 – No Action | $5,000 | $0 |
| Alternative 2 – Federal Decommission | $8,000 | $3,000 |
| Alternative 3 – HHPR | $5,000 | $0 |

Notes: 2024 price level; all values rounded to the nearest thousand.

The average annual costs associated with the alternatives and O&M costs of implementation for the No Action and FWFI alternatives are summarized in **Table 18**.

**Table 18. Average Annual Costs of Alternative Implementation (2024$)**

| Alternative | Implementation Costs | Average Annual Implementation Costs | Net Annual O&M Costs | Average Annual Costs |
|---|---|---|---|---|
| Alt 1 – No Action | $0 | $0 | $0 | $0 |
| Alt 2 – Federal Decommission | $3,598,000 | $110,000 | $3,000 | $113,000 |
| Alt 3 – HHPR | $19,749,000 | $606,000 | $0 | $606,000 |

Notes: 2024 price level; annualized over the 100-year evaluation period using a 2.75% discount rate; Average Annual Installation Cost includes interest during construction; implementation costs include contingency equal to 30.0%.

During the period of construction, a cofferdam will be put in place to control flows for the duration of the construction period, which will retain most of the flood protection provided by the existing dam.

## D.5 RESULTS OF THE ECONOMIC ANALYSIS

Benefits and costs over the period of analysis were annualized to allow for a direct comparison of average annual benefits to average annual costs. The benefits and costs used a price level of 2024 dollars and annualized using a discount rate of 2.75 percent over the 100-year evaluation period. **Table 19** summarizes the analysis results.

**Table 19. Benefit-Cost Analysis Summary (2024$)**

| Alternative | Average Annual Costs | Average Annual Benefits | Average Annual Net Benefits | Benefit-Cost Ratio (BCR) |
|---|---|---|---|---|
| Alternative 1 – No Action | $0 | $0 | $0 | 1.0:1.0 |
| Alternative 2 – Federal Decommission | $113,000 | -$210,000 | -$323,000 | -1.9:1.0 |
| Alternative 3 – HHPR | $606,000 | -$5,000 | -$611,000 | -0.0:1.0 |

Notes: 2024 price level; annualized over the 100-year evaluation period using a 2.75% discount rate; Average Annual Cost includes interest during construction; all $ values rounded to the nearest thousand.

## D.6 REGIONAL ECONOMIC ANALYSIS

A regional economic analysis was conducted by the NRCS economist. This calculated the regional impacts of the construction activities for the four alternatives, and the value-added flood damage reduction benefits using the IMPLAN model for the state of Texas. For the federally assisted alternatives (Alternative 3 and Alternative 4), most of the local cost-share dollars would be funded by a Texas State Government agency, not Karnes County, so it made more sense to use the state as the economic impacted area. The IMPLAN model was used, using standard NRCS procedures. The analysis was conducted for the recommended Alternative 3 & 4 as well as the decommissioning. **Table 20 to Table 24** below show the results of the regional economic analysis.

**Table 19 Annual Flood Damage Benefits**

| IMPLAN Sectors | Benefits |
|---|---|
| 6001 Proprietor Income | $0 |
| 10006 Households 70-100k | $79,565 |
| **Total** | **$79,565** |

Note: Proprietor Income – Farm Damages. Households – Structural and Infrastructure Damages vs Decomissioning

**Table 23 Annual Flood Damage Impacts (Alt 5)**

| Annual Flood Damage Impacts | Impact Type | Employment | Labor Income | Value Added | Output |
|---|---|---|---|---|---|
| | Direct | - | $397,000.00 | $397,000.00 | $397,000.00 |
| | Indirect | - | $0.00 | $0.00 | $0.00 |
| | Induced | 1.39 | $81,974.13 | $151,460.35 | $265,911.89 |
| | **Total Effect** | 1.39 | $478,974.13 | $548,460.35 | $662,911.89 |
| Alternative 2 Damages | | 2.90 | 358,244.38 | 503,397.17 | 742,477.45 |

Total Benefits Saved – Decommissioning vs Recommended Plan is $500,254 Annual Flood Benefits.

**Table 24 Construction Costs**

| Cost Item | PL-83-566 | Other funds | Total | IMPLAN Sectors | |
|---|---|---|---|---|---|
| Construction | $8,753,000 | $4,714,000 | $13,467,000 | 62 | construction of highways, streets, bridges |
| Engineering | $1,347,000 | $- | $1,347,000 | 457 | Architectural, engineering, and related services |
| Permits | | $269,000 | $269,000 | 541 | State Local Gov |
| Project Administration | $1,601,000 | $15,000 | $1,616,000 | 544 | Federal Admin for Fed Share |
| **Total** | **$11,701,000** | **$4,998,000** | **$15,098,000** | | |

**The construction costs are broken up and thus will have a different impact on the regional analysis.**

**Table 25 Construction Impacts**

| Impact Type | Employment | Labor Income | Value Added | Output |
|---|---|---|---|---|
| Direct Effect | 76.24 | $5,880,656.83 | $8,137,412.77 | $16,699,000.00 |
| Indirect Effect | 38.45 | $2,935,339.38 | $5,701,040.34 | $11,036,148.27 |
| Induced Effect | 45.47 | $2,649,439.18 | $4,924,797.21 | $8,668,571.62 |
| Total Effect | 160.17 | 11,465,435.38 | 18,763,250.32 | 36,403,719.89 |
| Multipliers | 9.59 | 0.69 | 1.12 | 2.18 |
| | Jobs per $1m | | | |

**The construction impacts will lead to 10 jobs per $1 million spent. The total effect to the Texas Economy is nearly $37 million.**

**Table 26 Regional Economic Benefits**

| Regional Economic Benefits (Texas) | No Action | Alternative 2 | Alternative 4 | Alternative 4 |
|---|---|---|---|---|
| Job-Years of Employment Created by Construction | - | 15.47 | 76.24 | 85.25 |
| RED Benefits to Texas Economy During Construction (One-time benefits) | $0 (Baseline) | | | |
| Total Sales During Construction to Texas Economy | $0 | $4,048,206 | $18,763,250 | $21,158,867 |

## D.7 APPENDIX A – STRUCTURE INVENTORY

### D.7.1 Extent of Structure Inventory

The structure inventory comprises residential and nonresidential structures located within the maximum flood extent for the combined sunny day breach inundation zone plus the 500-year decommission scenario with a 200 foot buffer.

### D.7.2 Structure Inventory Cleanup

**INITIAL PARCEL/STRUCTURE CLEANUP**

**Methodology:**

1. Cleaned up the dataset for inundation so it was selectable.
2. Selected parcels that fell in the inundation zone to narrow the search.
3. Selected the buildings that fell on those parcels from step 2 to create a smaller dataset of buildings.
4. Selected the buildings from step 3 that intersected the inundation zone.
5. Re-selected the parcels that were associated with the buildings from step 4.
    a. Removed any parcels that did not fall in the use code list
6. Created centroids of the parcels from step 5 to create a "dot" of each impacted parcel.

Reducing selection set from above:

1. Clipped inundation layer to the impacted buildings.
2. Removed parcels with inundation less than 10 sq ft. impacting a structure.
3. Removed parcel records that had a "LevelNum" attribute of 2 or greater.

Spatial Join (Parcels):

1. Joined the parcel records from step 3 above and the buildings to get a count of structures per owner.
2. Created a field called "Stru" to populate with the structure count by parcel. (This was done using the spatial join and intersect. Therefore, this resulted in multiple structures being listed as the structure(s) overlapped multiple parcels.)

Spatial Join (Buildings):

1. Created a spatial join between the building and the parcel(s) it intersects.
2. Created centroids of the buildings.
3. Jointed the building centroid with the dataset created in step 1.

**STRUCTURE CLEANUP AND FLOOD DEPTHS**

**Methodology for Exhibit 2A structure points and "others" structure points:**

1. The structure points were separated to be those within the area identified in Exhibit 2A and those that are not. They are identified as "others".

2. To clean up the structure points in the Exhibit 2A area, aerial imagery was used, and the points were either moved to the primary structure or removed. This was done by using Esri default imagery and the point data sets.
3. Points were moved to the primary structures on a parcel. Points removed that were on sheds, garages, or other unoccupied structures.
4. None of the points for the "other" dataset were moved. They remained in their location and parcel as per the original structure dataset.