

# **ARKANSAS RIVER CORRIDOR**

## *Appendix G: Civil Engineering*



# ARKANSAS RIVER CORRIDOR, TULSA COUNTY, OKLAHOMA

## Introduction

The Arkansas River is a water resource serving numerous nationally significant purposes. The river has historically served as a nationally significant resource for aquatic and terrestrial habitat of the nation's wildlife that live, breed, and migrate through the Arkansas River ecosystem. This includes federally endangered Interior Least Tern (Least Tern, *Sterna antillarum*), a nationally significant resource, and one federally threatened bird species, the Piping Plover (*Charadrius melodus*) as well as a plethora of native species and migratory waterfowl that support a healthy and functional riverine ecosystem. Keystone Lake and its dam located along the Arkansas River play vital roles in supporting the continued provision for these species, as well as many other purposes. In particular, the lake and dam provide flood risk management benefits, contribute to the eleven reservoir system operation of the McClellan-Kerr Arkansas River Navigation System, provide clean and efficient power through the associated hydropower plant, and provide a source of water for municipal and industrial uses. However, construction, operation, and maintenance of the Keystone Dam, lake, associated hydropower operations and other multi-purposes have significantly degraded the riverine ecosystem structure, function, and dynamic processes below Keystone Dam on the Arkansas River within Tulsa County, Oklahoma.

## Purpose

This study is in response to the Section 3132 authorization of the 2007 WRDA. The purpose of this study is to evaluate the aquatic ecosystem restoration components of the October 2005 Arkansas River Corridor Master Plan (ARC Master Plan) and determine if there is a Federal Interest that aligns with the Corps of Engineers' ecosystem restoration mission.

## Study Authority

The Arkansas River Corridor study is authorized in the Water Resources Development Act (WRDA) of 2007, Section 3132.

Section 3132. Arkansas River Corridor.

- (a) IN GENERAL. – The Secretary is authorized to participate in the ecosystem restoration, recreation, and flood damage reduction components of the Arkansas River Corridor Master Plan dated October 2005. The Secretary shall coordinate with appropriate representatives in the vicinity of Tulsa, Oklahoma, including representatives of Tulsa County and surrounding communities and the Indian Nations Council of Governments.
- (b) AUTHORIZATION OF APPROPRIATIONS. – There is authorized to be appropriated \$50,000,000 to carry out this section.

## Non-Federal Sponsor

Tulsa County is the non-federal sponsor for the Arkansas River Corridor feasibility study. An amended feasibility cost-sharing agreement was executed in May 2015.

## Recommended Plan

Alternative 5 is the National Ecosystem Restoration (NER) Plan and includes construction of a pool structure at River Mile 530 to regulate flow in the Arkansas River, a rock riffle feature associated wetland plantings at Prattville Creek, and construction of a sandbar island near Broken Arrow, OK. With the implementation of the NER plan, more natural river flow would return to 42 river miles of the Arkansas River within the study area. The NER plan would provide approximately 2,144 acres of additional riverine habitat, nearly doubling the amount of currently available habitat under low flow conditions. Also five acres of restored wetlands, and three acres of reliable sandbar island habitat where none currently succeed, would be restored as part of the NER plan. Shoreline, river, backwater, slackwater, wetland, and sandbar island habitat quality would all be improved generating an overall increase in the ecosystem quality and carrying capacity of the corridor. Current operation of Keystone Dam would not be changed. Additional water and flow would remain within the existing banks of the river and would not increase the flood elevation, nor downstream or backwater flooding.

## GENERAL DESCRIPTION

The purpose of this appendix is to outline conceptual engineering designs for the measures identified during the study process. The measures are outlined in the main body of this study report. Civil engineering efforts were conducted to provide a foundation for the development of a government estimate as well as a visualization of the measures. The management measures included two possible locations (but not both) for a pool structure; rock riffle structures; and wetland and riparian plantings at Prattville Creek and/or I-44/Riverside. These measures were combined into 11 plans, consisting of stand-alone plans and partially formed plans, for populating Institute for Water Resources (IWR) Planning Suite to generate alternatives, or combination of the plans. All plans assumed South Tulsa/Jenks low water dam is in place and functioning as the Future With Project Condition. Benefits and first costs were developed for each of the 11 partially formed/stand-alone plans as described in the main body of this report. The array of plans are:

- Pool structure located at river mile 531 (former site of Lake Keystone Project reregulating dam)
- Pool structure located at river mile 530
- Constructed Least Tern Island
- Rock Riffle Structures at Prattville Creek
- Rock Riffle Structures and Wetland Plantings at Prattville Creek
- Rock Riffle Structures and Riparian Planting at Prattville Creek
- Rock Riffle Structures, Wetland Plantings, and Riparian Plantings at Prattville Creek
- Rock Riffle Structures at I-44 Riverside
- Rock Riffle Structures and Wetland Plantings at I-44 Riverside
- Rock Riffle Structures and Riparian Planting at I-44 Riverside
- Rock Riffle Structures, Wetland Plantings, and Riparian Plantings at I-44 Riverside

## RECOMMENDED PLAN

### SUMMARY OF MEASURES

**Pool Control Structure:** In April of 2015 CH2M Hill produced the “Arkansas River Low Water Dams and Public Access/Recreational Improvements” report for Tulsa County, the Non-Federal sponsor. The report included schematic designs and cost estimates including an analysis and concept for a low water dam in the Sand Springs area. The CH2M efforts serve as the design basis for the pool control structure measure carried forward in this study. The concept design and basis of estimate for the pool control structure are the same regardless of chosen location for the structure at this stage in the project.

The key to reaching the restoration goals is being able to deliver the full pool of water

when needed for sustained flow and providing at least seasonal fish/egg passage, particularly during spring when there are sustained flood pool releases from Keystone. Delivery a sustained flow and fish/egg passage are key design requirements and will be considered constraints during the design phase following feasibility. The initial design concept featured a combination of full and partial height gates. Full height gates allow the passage needed during bigger flow events and the ability to use the full pool and the partial height gates allow for water management when maintaining the restoration goal of 1,000 cfs.

### **Design Constraints**

Constraints were identified based on meetings with US Fish and Wildlife Service and OK Department of Environmental Quality on July 19, 2017 and a site visit to observe 1000 cfs flow on September 11, 2017. The resource agencies provided input into dam design and operation.

- Pool Structure should be located to provide storage to sustain 1000 cfs during times of non-hydropower production ~ about three days.
- Operation of structure will not affect hydropower production, or other operations of Keystone Dam.
- Pool Structure should be able to open gates allow fish eggs to tumble downstream on the river bed. Obermeyer gates allow this.
- Pool Structure should allow fish passage both up and downstream during spawning season.
- Design will fully consider life safety issues that have been previously associated with structures below Keystone Dam.

The pool control structure is shown in the conceptual images and design drawings below. The images depict gates in operation to maintain pool between peak demand weekday hydropower generation and gates down to allow for unregulated river flow and unobstructed fish/egg/sediment passage. Design drawings are conceptual and will be further developed during the PED phase to account for the project location described in this study and the appropriate elevations. The structure will have a crest elevation of 638.5 feet. The Geotechnical Appendix contains rationale for an assumed founding depth of 610.0 feet. This is in line with the bottom elevation depicted on the concept design drawings developed by CH2M Hill. The structure is 1,900 feet in length with a total gate area of 8,192 square feet. The full-height gate section is 10 feet high.

Additional design assumptions for the pool control structure include: Rock anchors will be required; concrete will need to be cooled for mass placement; the river will be diverted using the sand material excavated from the dam footprint to construct a temporary earthen coffer dam in conjunction with a portable cofferdam system; dewatering will be required; rock excavation will be required; grouted rock will be placed on the downstream side of the dam for ballast and scour protection; Obermeyer Gates will be used for water control (concept shown below); gate equipment will be housed in new maintenance structure; a maintenance access bridge will span the structure; soldier pile retaining walls with cast in place concrete facing will extend up and down river on each bank from

midpoint of pool structure.

### **Operation of Structure**

The structure will be designed to sustain the 1000 cfs flow during non-hydropower production. Hydropower production at Keystone Dam is for peak power only. Typically hydropower pulses from Keystone occur each weekday evening from about 1700-2100. As hydropower pulses are released from Keystone Lake, water will be stored behind the recommended pool structure downstream of Keystone Dam. Any water released during hydropower production that is not needed to maintain the 1000 cfs flow will be released from the downstream pool structure. When hydropower is not being produced the pool control structure would operate to release 1000 cfs flows. It is estimated that storage in the pool will last approximately 2.5 days during the weekend when hydropower is not typically produced. The operation will be closely monitored during the adaptive management phase until performance of system is optimized.

### **Safety Considerations**

From 1968 to 1985 a reregulation dam located 7.8 miles downstream of Keystone Dam was in operation for the purpose of smoothing hydropower releases and providing water quality control flows. This reregulation dam was removed in part due to safety concerns. The design of the former dam created a roll over effect on the downstream side due to the shape of the structure. If a person were to fall into the water, the strength of the churning water would create a life threatening hazard. Design features (e.g. a gentler slope on the downstream side of the structure) will be incorporated to reduce dangerous roll over churn seen in the previous design.

In addition, project security requirements for the non-federal sponsor to ensure public safety and physical security of the structure will be developed in the PED phase of this project. Physical security plans will be developed in accordance with ER 111-2-1150.

**Quantity Summary for Pool Control Structure:** Quantification of concept design elements based on the above criteria and assumptions was performed by CH2M Hill and included in the detail report of their cost estimate (shown below but refer to Cost Appendix for detail). This includes 269 rock anchors, 26 Obermeyer Gates, and a 20 foot by 40 foot maintenance building. These quantities have been included in the new MCACES estimate found in the Cost Appendix to this report. Quantity verification or checks performed as back up for the estimate are included in the Cost Appendix.



Project  
390524  
Design Stage

Sand Springs  
390524  
Schematic Design

Estimator:  
Rev No / Date:  
Estimate Class:

Jones T  
02 - 04/24/2014  
Class 3

Detail Report

Table with columns: Bid Item, Area, Work Pkg, Trade Pkg, Description, Takeoff Quantity, Labor Man Hrs, Labor Amount, Material Amount, Sub Amount, Equip Amount, Other Amount, Total Cost/Unit, Total Amount, Grand Total. It lists various construction items like concrete work, reinforcement, and formwork for a low water dam and pedestrian bridge.





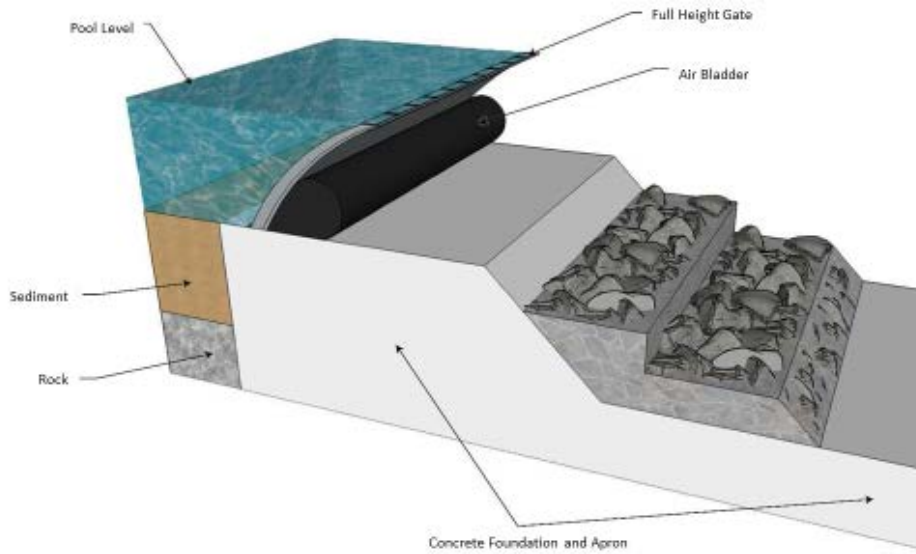
Project: Sand Springs  
 Project No.: 390524  
 Design Stage: Schematic Design

Estimator: Jones T  
 Rev No / Date: 02 - 04/24/2014  
 Estimate Class: Class 3

Detail Report

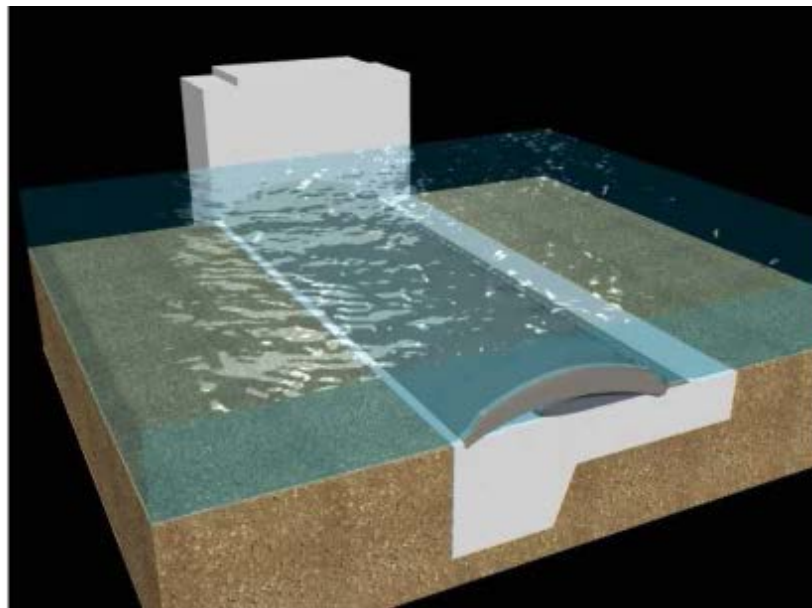
Bid Item	Area	Work Pkg	Trade Pkg	Description	Takeoff Quantity	Labor Man Hrs	Labor Amount	Material Amount	Sub Amount	Equip Amount	Other Amount	Total Cost/Unit	Total Amount	Grand Total
				<b>Pedestrian Bridge @ Low Dam Crossing</b>										
				Fabricated bridge, concrete in place, no reinforcing beams, includes shoring	15000 SF	1,440.0	87,204	64,503	-	16,902	-	8913 /SF	140,279	211,445
				Precast concrete beams (Type 14B)	3,810 SF		-	3,413,570	-	-	-	370.00 /SF	1,411,200	2,981,137
				Precast concrete beams (Type 14B)	35,100 SF		-	3,82,240	-	-	-	14.00 /SF	314,440	765,141
				<b>30-04 Fabricated Bridges</b>	<b>38,150 SF</b>	<b>4,209.7</b>	<b>228,733</b>	<b>271,221</b>	<b>1,846,160</b>	<b>18,100</b>	<b>-</b>	<b>54.82 /SF</b>	<b>2,462,218</b>	<b>3,614,201</b>
				<b>30.0 Exterior Improvements</b>	<b>1.00 EA</b>	<b>4,209.7</b>	<b>228,733</b>	<b>271,221</b>	<b>1,846,160</b>	<b>18,100</b>	<b>-</b>	<b>2,462,217.93 /EA</b>	<b>2,462,218</b>	<b>3,614,201</b>
				<b>020 Pedestrian Bridges</b>	<b>1.00 EA</b>	<b>4,209.7</b>	<b>228,733</b>	<b>271,221</b>	<b>1,846,160</b>	<b>18,100</b>	<b>-</b>	<b>2,462,217.93 /EA</b>	<b>2,462,218</b>	<b>3,614,201</b>
				<b>Structures</b>										
				<b>General Construction</b>										
				<b>Fabricated Engineered Structures</b>										
				<b>25x40 Dam Control Building</b>	1.00 EA				80,000	-	-	80,000.00 /EA	80,000	118,201
				25x40 Dam Control Building (sketched)	1.00 EA				80,000	-	-	80,000.00 /EA	80,000	118,201
				<b>13-04 Fabricated Engineered Structures</b>	<b>1.00 EA</b>				<b>80,000</b>	<b>-</b>	<b>-</b>	<b>80,000.00 /EA</b>	<b>80,000</b>	<b>118,201</b>
				<b>13.0 Special Construction</b>	<b>1.00 EA</b>				<b>80,000</b>	<b>-</b>	<b>-</b>	<b>80,000.00 /EA</b>	<b>80,000</b>	<b>118,201</b>
				<b>000 Structures</b>	<b>1.00 EA</b>				<b>80,000</b>	<b>-</b>	<b>-</b>	<b>80,000.00 /EA</b>	<b>80,000</b>	<b>118,201</b>
				<b>Retaining Walls</b>										
				<b>Site Civil</b>										
				<b>31-00 Earthworks, Site</b>										
				<b>Mechanical Excavation</b>										
				Manure Head Roads with side & Operator	2.00 HR	2.8	90	53	-	134	-	137.91 /HR	276	382
				Dust Control Operations	10.00 LF	16.9	201	81	-	81	-	161.89 /LF	1,619	2,123
				Bank & Track for Equipment, Lube, Oil, Service & Fueler	1.00 LF	1.8	43	11	-	66	-	117.71 /LF	118	166
				Excavating, sub base measure, 3 C.Y. backfill 20' C.Y. haul, backfill, hydraulic, crawler mounted, excavator track loading	4,000.00 BCY	30.8	1,374	-	-	3,578	-	1.23 /BCY	4,933	6,344
				Hauling, uncrushed stone, medium to coarse, 1/2 mile round trip, 2.0 loads/hr, base soil rate 15.5 v dump trailer off highway, excludes loading	4,000.00 HRY	44.3	1,869	-	-	12,033	-	3.43 /HRY	13,302	17,654
				<b>Mechanical Excavation</b>	<b>4,000.00 CY</b>	<b>30.7</b>	<b>3,875</b>	<b>64</b>	<b>16,808</b>	<b>-</b>	<b>-</b>	<b>6.13 /CY</b>	<b>20,827</b>	<b>29,198</b>
				<b>31-00 Earthworks, Site</b>	<b>1.00 LF</b>	<b>92.7</b>	<b>3,875</b>	<b>64</b>	<b>16,808</b>	<b>-</b>	<b>-</b>	<b>20,827.40 /LF</b>	<b>20,827</b>	<b>29,198</b>
				<b>31.0 Site Civil</b>	<b>1.00 LF</b>	<b>92.7</b>	<b>3,875</b>	<b>64</b>	<b>16,808</b>	<b>-</b>	<b>-</b>	<b>20,827.40 /LF</b>	<b>20,827</b>	<b>29,198</b>
				<b>Excavator Improvements</b>										
				<b>32-02 Retaining Walls</b>										
				<b>Retaining Wall - 5 ea Wall 10' Ht.</b>										
				Bottom beams 6 leg, no tyrod heads, in place, 15 22D 2 line of brace	2,000.00 SF	540.0	25,487	30,288	-	17,364	-	36.53 /SF	73,051	114,064
				Golden beams 6 leg, no tyrod heads, in place, 15 22D 2 line of brace	30.00 SF	720.0	31,874	16,659	-	2,017	-	1,665.00 /SF	50,891	75,093
				Shotcrete 14 high includes formwork, reinforcing steel, concrete, placing and finishing	74.07 CY	376.3	13,806	11,299	-	1,849	-	488.55 /CY	30,914	41,491
				<b>Retaining Wall - 5 ea Wall 20' Ht.</b>	<b>206.00 LF</b>	<b>1,820.0</b>	<b>75,005</b>	<b>89,159</b>	<b>20,430</b>	<b>-</b>	<b>-</b>	<b>788.70 /LF</b>	<b>163,744</b>	<b>218,100</b>
				Bottom beams 6 leg, no tyrod heads, in place, 15 22D 2 line of brace	4,000.00 SF	1,080.0	50,975	60,499	-	34,727	-	36.63 /SF	146,921	216,919
				Golden beams 6 leg, no tyrod heads, in place, 15 22D 2 line of brace	30.00 SF	720.0	31,874	16,659	-	2,017	-	1,665.00 /SF	50,891	75,093
				Shotcrete 14 high includes formwork, reinforcing steel, concrete, placing and finishing	148.15 CY	740.5	26,615	22,519	-	2,098	-	488.55 /CY	60,231	84,901
				<b>Retaining Wall - 5 ea Wall 20' Ht.</b>	<b>206.00 LF</b>	<b>2,640.8</b>	<b>118,807</b>	<b>99,659</b>	<b>29,817</b>	<b>-</b>	<b>-</b>	<b>1,284.88 /LF</b>	<b>268,918</b>	<b>368,228</b>
				<b>32-02 Retaining Walls</b>	<b>406.00 LF</b>	<b>4,170.8</b>	<b>192,711</b>	<b>187,877</b>	<b>89,275</b>	<b>-</b>	<b>-</b>	<b>1,026.88 /LF</b>	<b>419,862</b>	<b>603,294</b>
				<b>32.0 Exterior Improvements</b>	<b>1.00 LF</b>	<b>4,170.8</b>	<b>192,711</b>	<b>187,877</b>	<b>89,275</b>	<b>-</b>	<b>-</b>	<b>419,861.83 /LF</b>	<b>419,862</b>	<b>603,294</b>
				<b>000 Retaining Walls</b>	<b>1,000.00 LF</b>	<b>4,263.8</b>	<b>197,880</b>	<b>187,741</b>	<b>76,862</b>	<b>-</b>	<b>-</b>	<b>431.19 /LF</b>	<b>431,139</b>	<b>612,619</b>
				<b>Utilities</b>										
				<b>26-00 Electrical Work</b>										
				<b>Site Lighting</b>										
				Site Lighting - Pedestrian Bridge	1.00 LF			173,000	-	-	-	173,000.00 /LF	173,000	251,178
				Site Lighting	1.00 LF			170,000	-	-	-	170,000.00 /LF	170,000	251,178
				<b>25-10 Site Electrical</b>	<b>1.00 LF</b>			<b>170,000</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>170,000.00 /LF</b>	<b>170,000</b>	<b>251,178</b>
				25.0 Electrical Work	1.00 LF			170,000	-	-	-	170,000.00 /LF	170,000	251,178
				110 Utilities	1.00 LF			170,000	-	-	-	170,000.00 /LF	170,000	251,178
				<b>5500 Low Water Dam &amp; Pedestrian Bridge</b>	<b>1,908.00 LF</b>	<b>195,642.7</b>	<b>7,018,445</b>	<b>12,453,269</b>	<b>10,470,605</b>	<b>1,619,862</b>	<b>-</b>	<b>16,642.03 /LF</b>	<b>31,662,201</b>	<b>45,940,640</b>





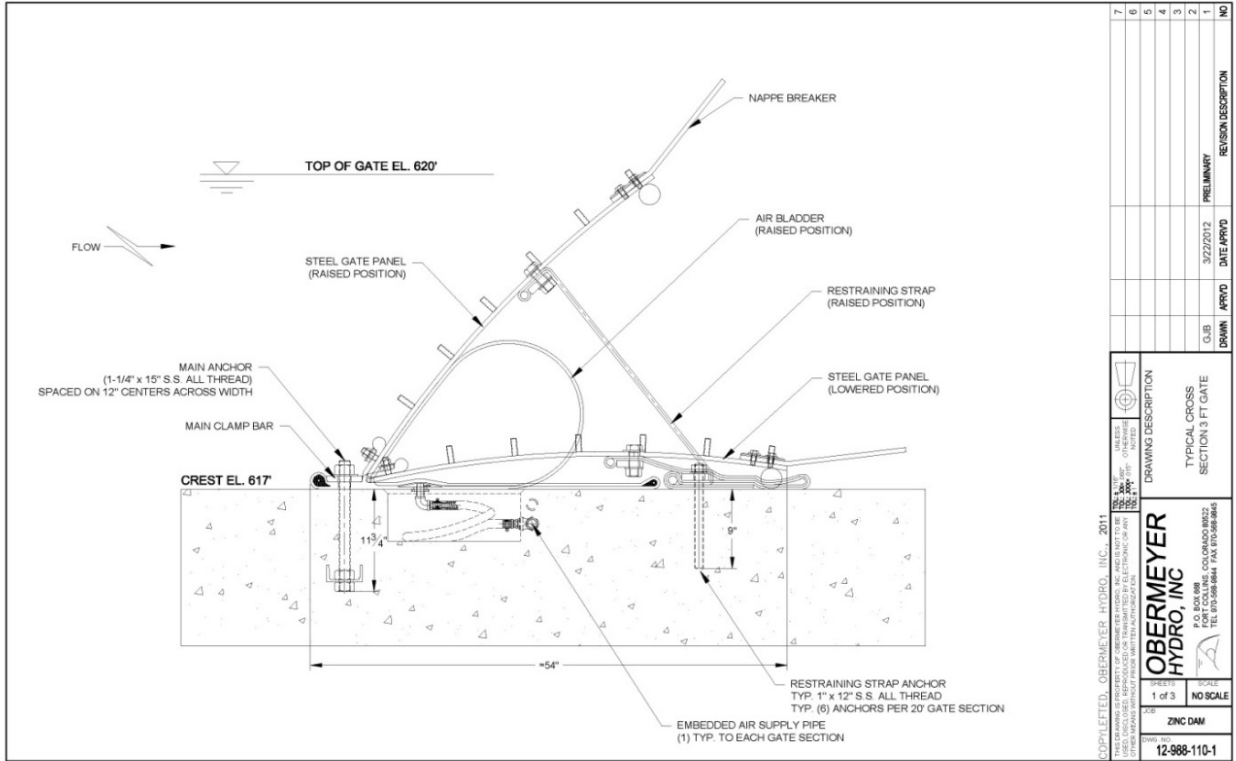
Pool Control Structure Concept Design

Note that the above image depicts gates in the up position maintain pool between peak demand weekday hydropower generation.

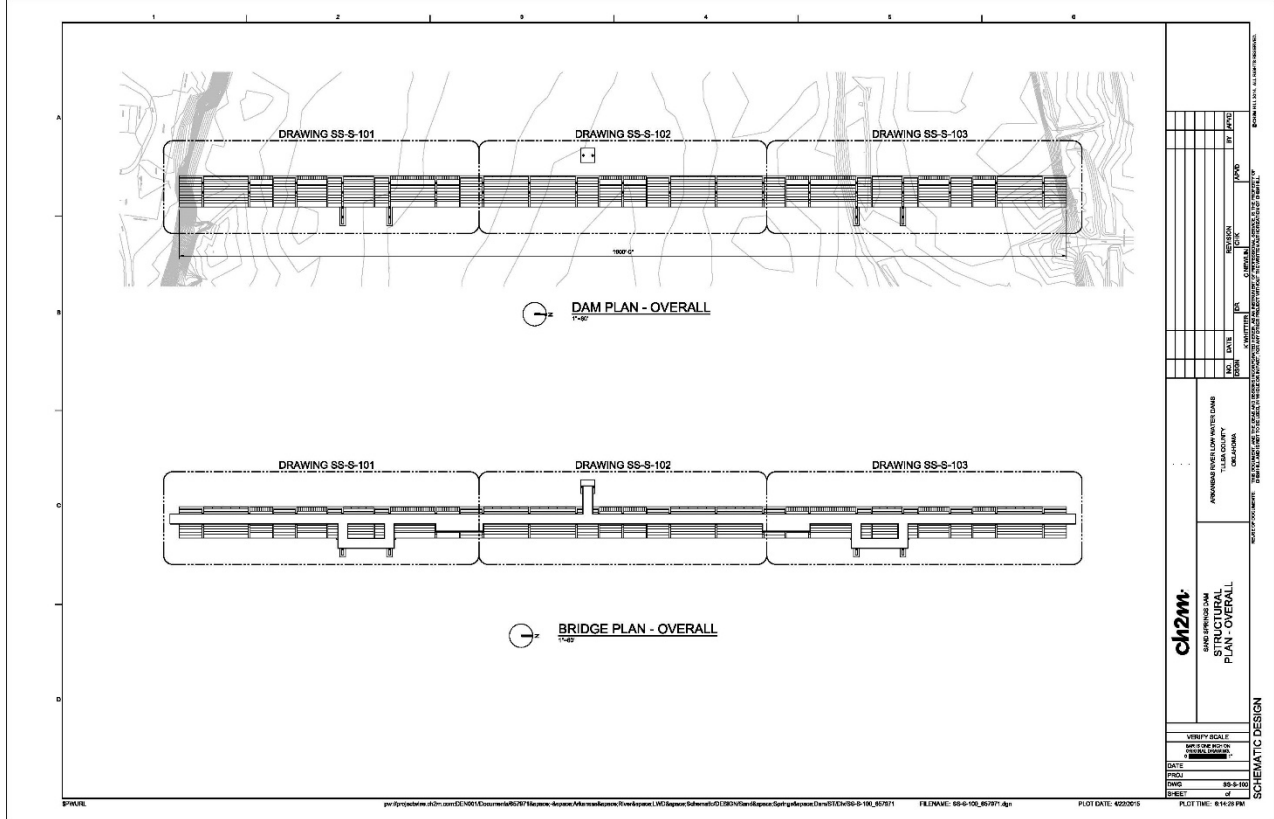


Pool Control Structure Concept Design

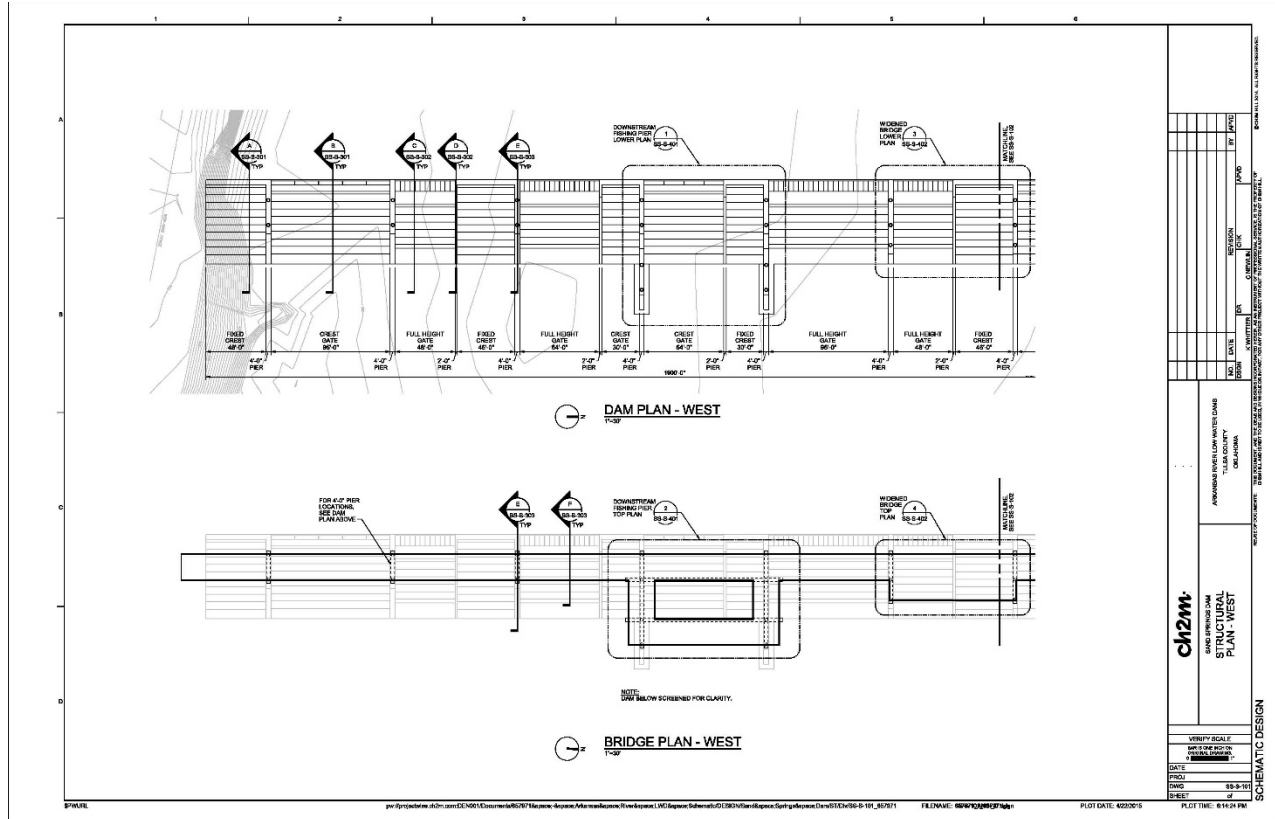
Note that the above image depicts the full height gates in the down position which will allow for unregulated river flow and unobstructed fish/egg/sediment passage during the monsoon season and associated flood pool releases.



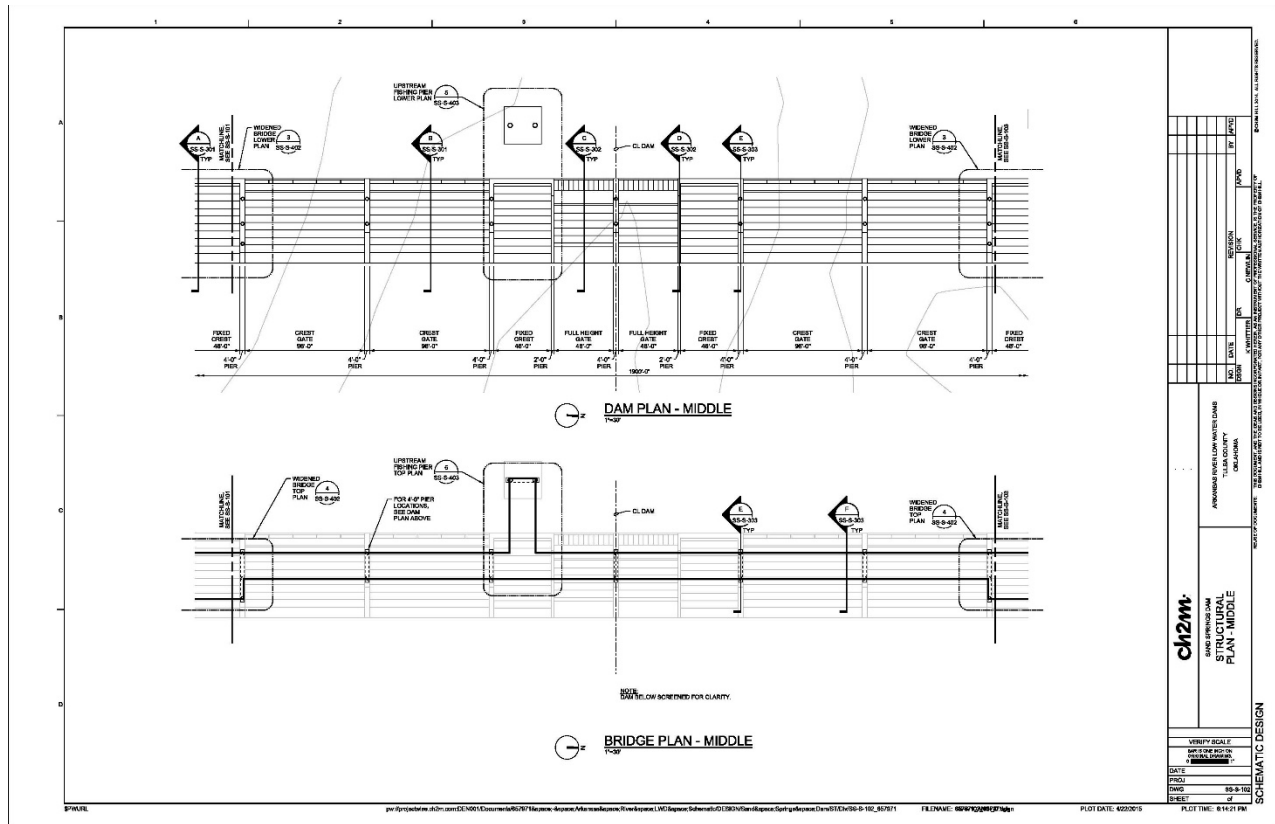
Note that the above is a representative image of an Obermeyer gate. During the Design Phase of the project the gates will be adapted and designed for use at the project location identified in this study.



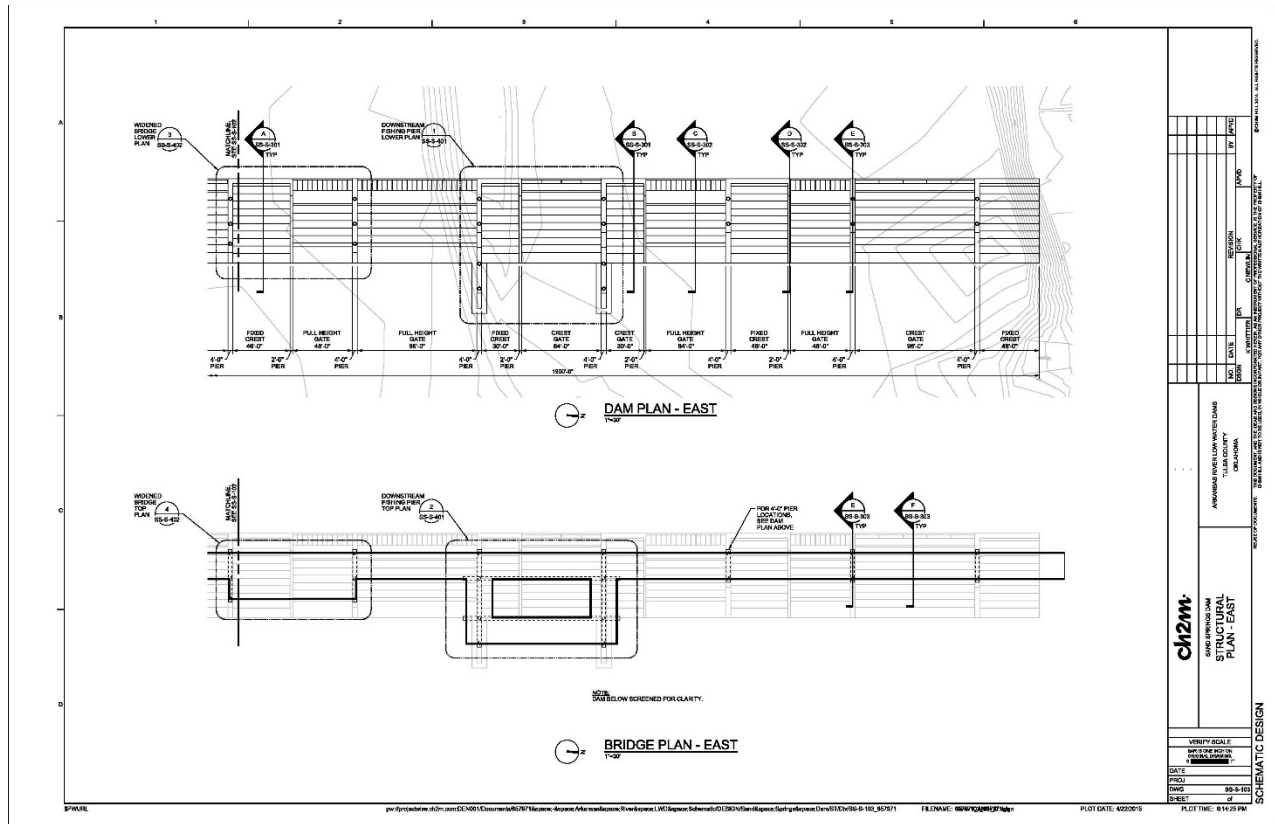
Note that the above is a conceptual design drawing. Final design will ensure correct dimensions and elevations for the project location identified in this study.



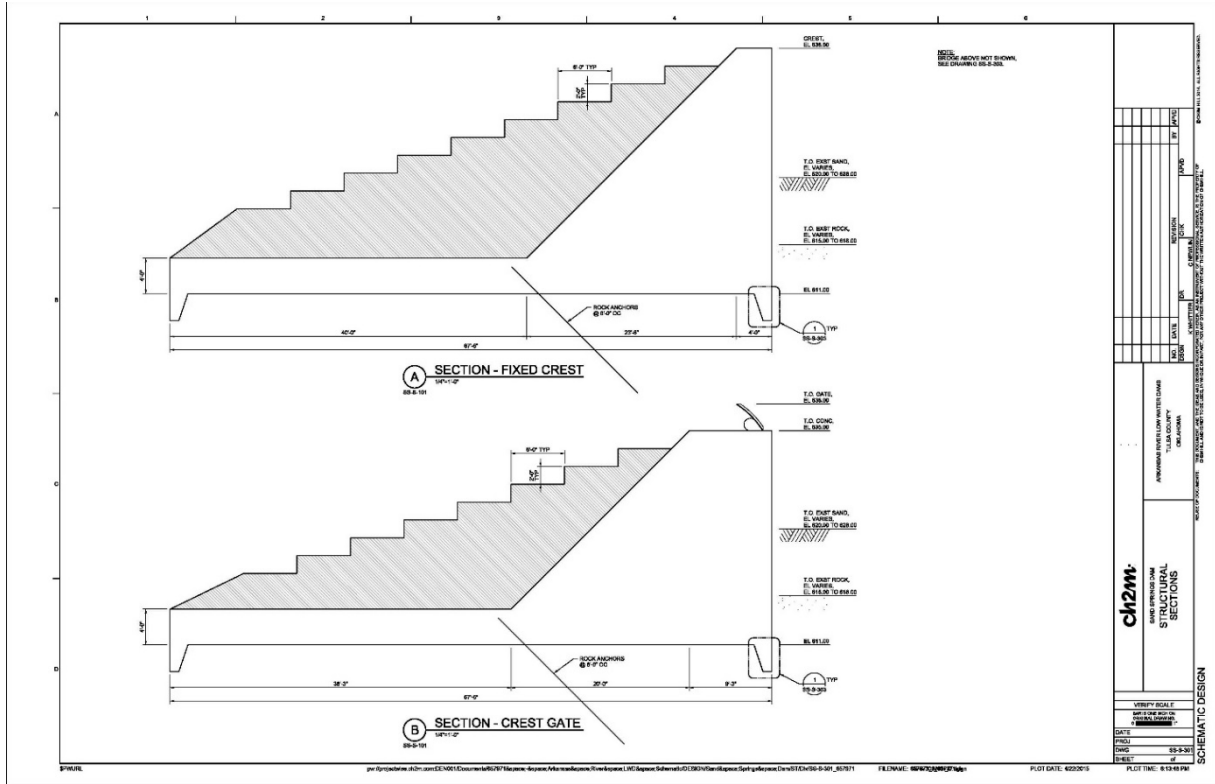
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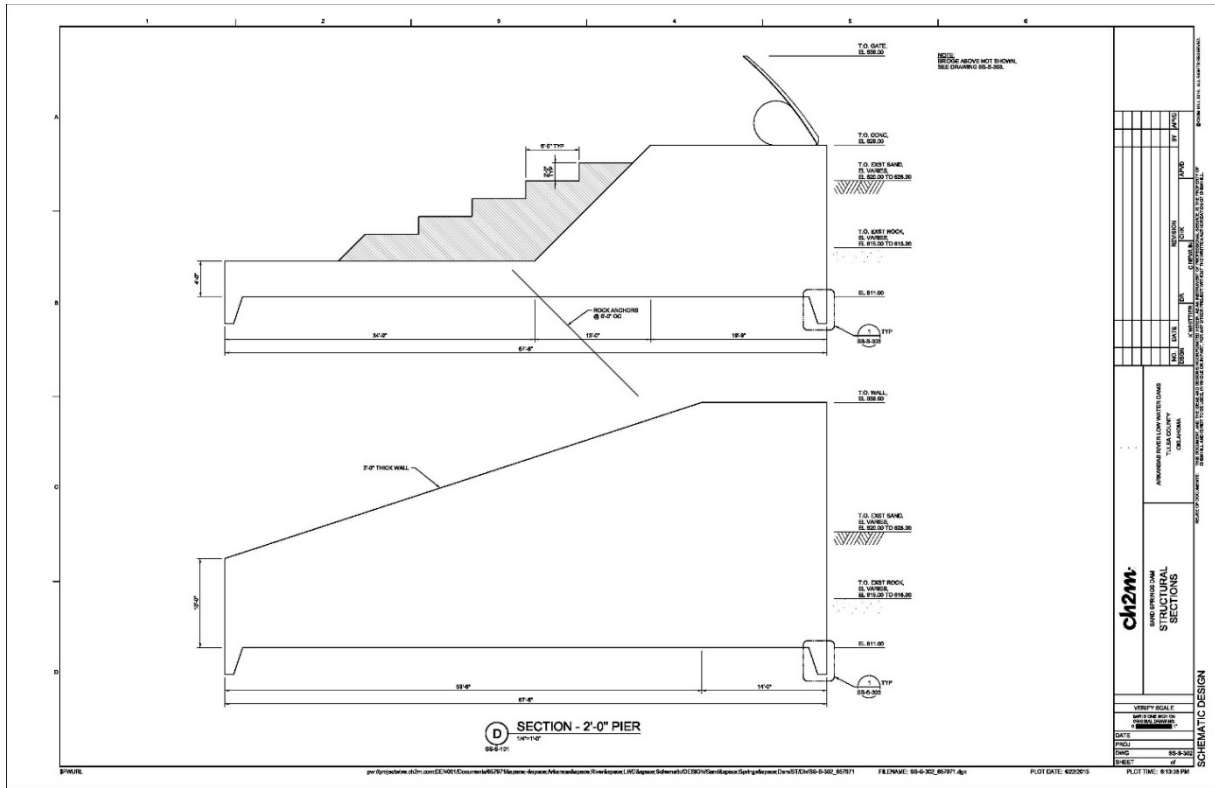
Note that the above is a conceptual design drawing. Final design will ensure correct dimensions and elevations for the project location identified in this study.



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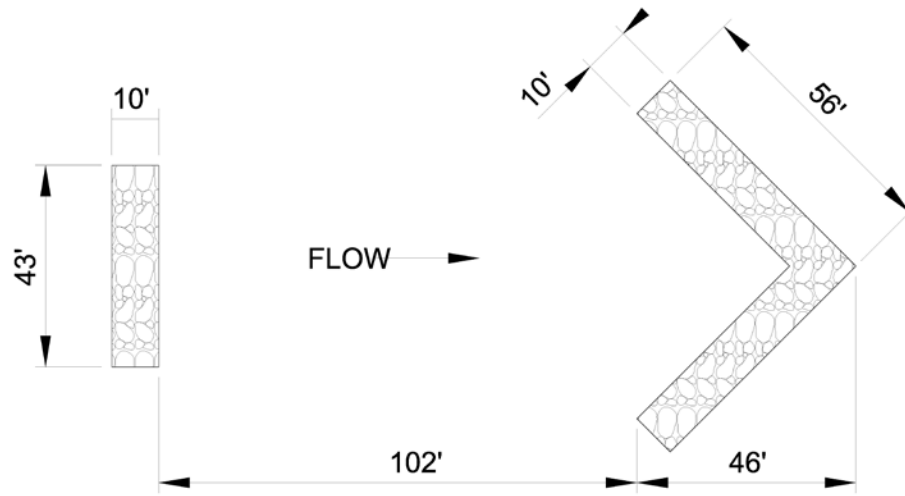
Note that the above is a conceptual design drawing. Final design will ensure correct dimensions and elevations for the project location identified in this study.



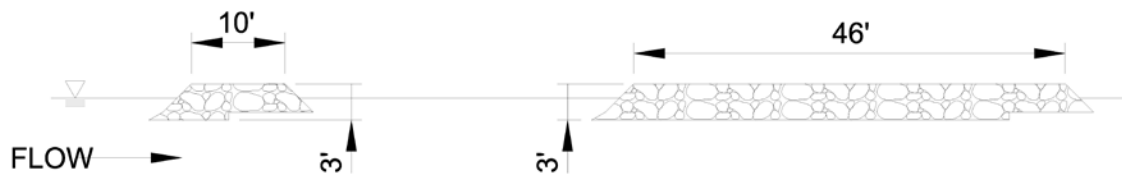
**Least Tern Island:** In 2003, the Oklahoma State University Biosystems Engineering Senior Design Team was selected by the U.S. Army Corps of Engineers (USACE) Tulsa District to conduct an analysis for the design of a least tern nesting habitat and the optimal location along the Arkansas River for implementation. The preliminary cost estimate was generated using the design criteria provided in the final report titled, "Designing an Island Habitat for the Interior Least Terns". The design criteria and critical features of work are summarized below.

The original analysis considered four separate design configurations and the design team constructed small scale flume models for testing and collecting data. From this analysis, it was recommended that the configuration shown in SK-1 be constructed in southern Broken Arrow. The selected site is located east of S. 145<sup>th</sup> E. Ave. and south of E. 131<sup>st</sup> St. S., directly south of the Indian Springs Sports Complex at the approximate location shown in SK-2.

**Quantity Summary for Least Tern Island:** This is a 5 acre island with structure dimensions of 43' x 10' x 3' (front) and 56' x 10' x 3' (back) for a total of 110 CY. Riprap should be assumed as 5,400 CY of 24" riprap for the front and back structures.

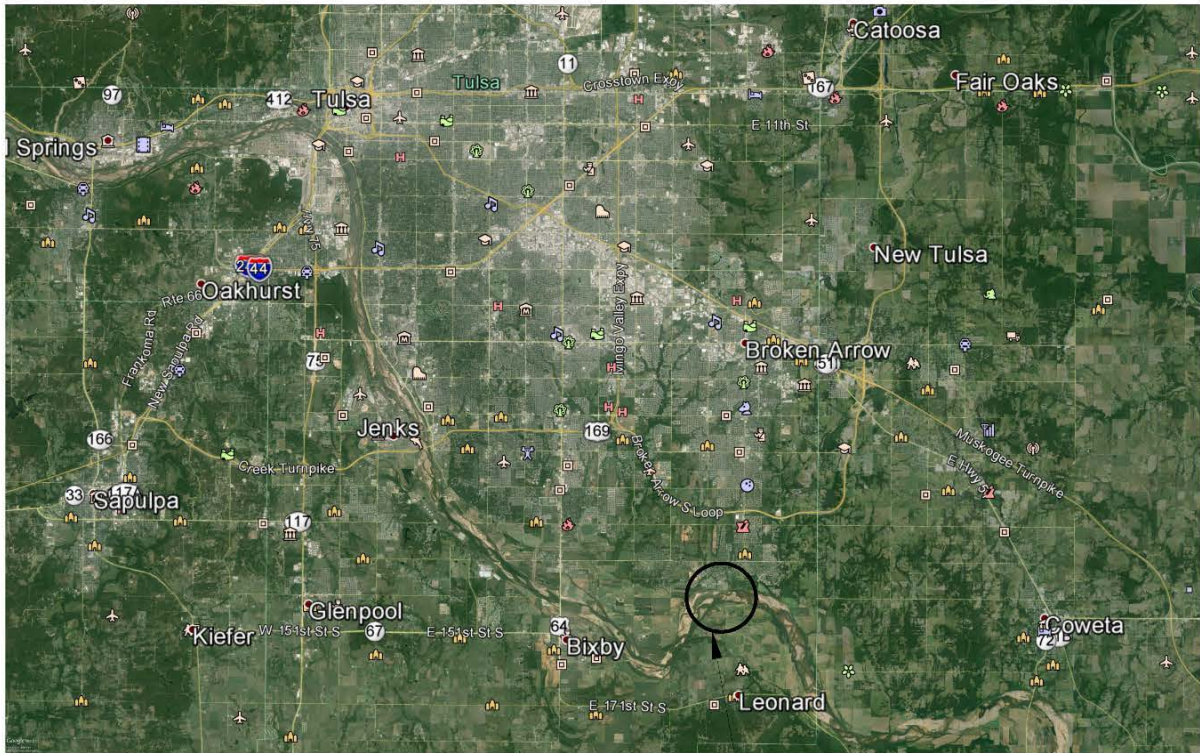


LEAST TERN ISLAND PLAN



LEAST TERN ISLAND PROFILE  30" DIAM. RIP RAP

U.S. ARMY CORPS OF ENGINEERS, TULSA DISTRICT	
<b>ARKANSAS RIVER CORRIDOR LEAST TERN ISLAND CONCEPT</b>	
	DESIGNER: N/A
	SCALE: NOT TO SCALE
	
DATE: 08/15/2016	
DRAWING: SK-1	



LEAST TERN  
ISLAND LOCATION



U.S. ARMY CORPS OF ENGINEERS, TULSA DISTRICT

**ARKANSAS RIVER CORRIDOR  
LEAST TERN ISLAND CONCEPT**



DESIGNER: N/A  
SCALE: NOT TO SCALE

DATE: 06/21/2017  
DRAWING: SK-2



**Prattville Creek Rock Riffle + Wetland Plantings:** This alternative includes the design and construction of the rocked riffle and riprap listed in the above alternative, with the addition of wetland type plantings. For this area, the wetland plantings are comprised of ornamental grasses. It is calculated that this alternative will require approximately 6,960 plants across the creek's embankment in order to restore the native habitat for wildlife. Design drawings for the plantings and rock structures are shown in SK-5 and SK-6 below.

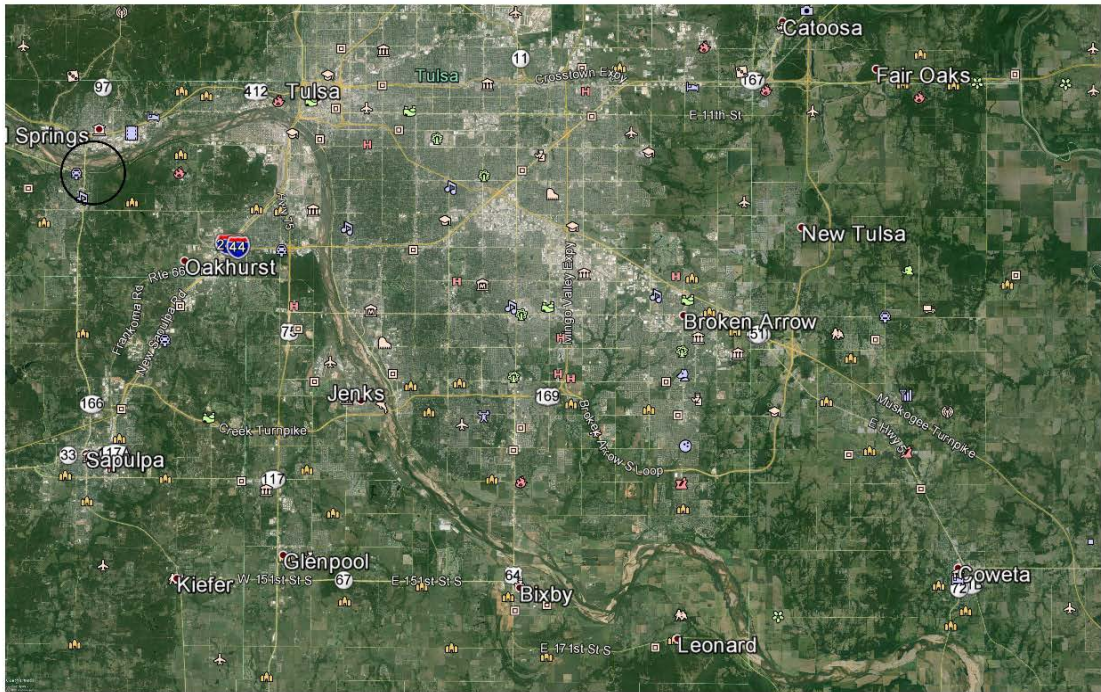
**Quantity Summary for Prattville Creek:** The estimated quantities for this stage in design are 4,640 CY of soil, 44 CY of 6" bedding stone, 383 CY of 24" riprap and 1,160 CY of 12" riprap. For plantings estimator should assume 6,960 wetland plantings (rushes, reeds, bulrushes), 15,600 riparian plantings (red-ossier dogwood & brush willow), and 2.5 acres of invasive species control.

**Screened Measures:** The below measures were considered in the array and screened out.

**Prattville Creek Rocked Riffle and Riprap:** Prattville Creek is located east of Highway 97 on the south bank of the Arkansas River in Sand Springs, Oklahoma. The ground elevation is at approximately 634 feet with a mouth width of approximately 80' (according to Google Earth). This alternative includes the construction of a rocked riffle structure made of size 24" riprap with a 6" thick aggregate bedding as well as lining the southern embankment with size 12" riprap. The preliminary design details are shown in SK-5 and SK-6 below.

**Prattville Creek Rock Riffle + Riparian Plantings:** This alternative includes the design and construction of the rocked riffle and riprap listed in the above alternative, with the addition of riparian type plantings. For this area, the riparian plantings are comprised of Red-Osier Dogwood trees and Brush Willows which have a minimum height of 3'-4' and a minimum caliper of 1". It is calculated that this alternative will require approximately 15,600 plants across the creek's embankment in order to restore the native habitat for wildlife. Design drawings for the plantings and rock structures are shown in SK-5 and SK-6 below.

**Prattville Creek Rock Riffle + Riparian Plantings + Wetland Plantings:** This alternative includes the design and construction of the rocked riffle and riprap listed in the above alternative, with the addition of the riparian planting alternative and the wetland planting alternative. Design drawings for the plantings and rock structures are shown in SK-5 and SK-6 below.



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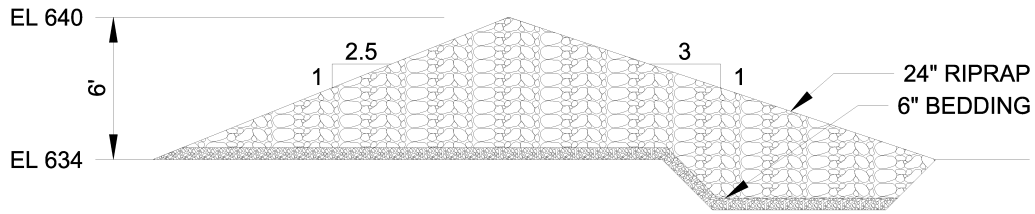
**ARKANSAS RIVER CORRIDOR  
PRATTVILLE CREEK**



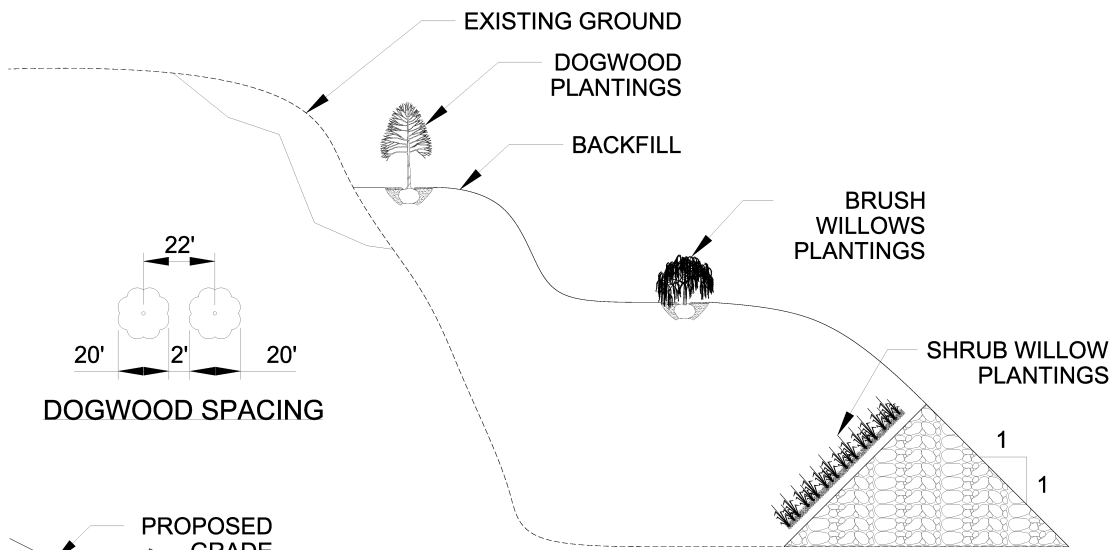
DESIGNER: N/A  
SCALE: NOT TO SCALE

DATE: 08/16/2016  
DRAWING: SK-5

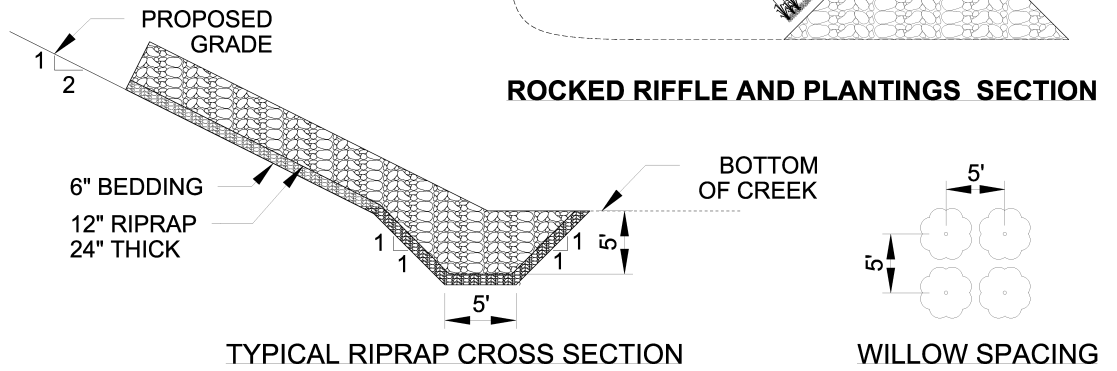




**ROCKED RIFFLE CROSS SECTION**



**ROCKED RIFFLE AND PLANTINGS SECTION**



**TYPICAL RIPRAP CROSS SECTION**

**WILLOW SPACING**

U.S. ARMY CORPS OF ENGINEERS, TULSA DISTRICT

**ARKANSAS RIVER CORRIDOR  
PRATTVILLE CREEK**



DESIGNER: N/A  
SCALE: NOT TO SCALE

DATE: 08/16/2016  
DRAWING: SK-6



**Screened Measures:** The below measures were considered in the array and screened out.

**I-44/Riverside Wing Deflectors + Rock Riffle:** Three slack water side channels exist along the eastern bank of the Arkansas River at the northwest corner of the intersection between Riverside Drive and Interstate 44. This alternative includes the design and construction of rocked riffle structures and stone wing deflectors within these channels in order to help control erosion and restore the native habitat for wildlife. The rocked riffle design is similar to that of the Cherry Creek structure and can be seen in SK-8 and SK-9 below. The wing deflectors are comprised of size 24" riprap structures which protrude 1/5<sup>th</sup> of the width of the river at an angle of 20 degrees as shown in SK-8. The combination of these designs prevent the river flows from eroding away the embankment. The preliminary design considered a river flow of 12,000 cubic feet per second (cfs) to 15,000 cfs. The structure is designed to be overtopped during higher flow events.

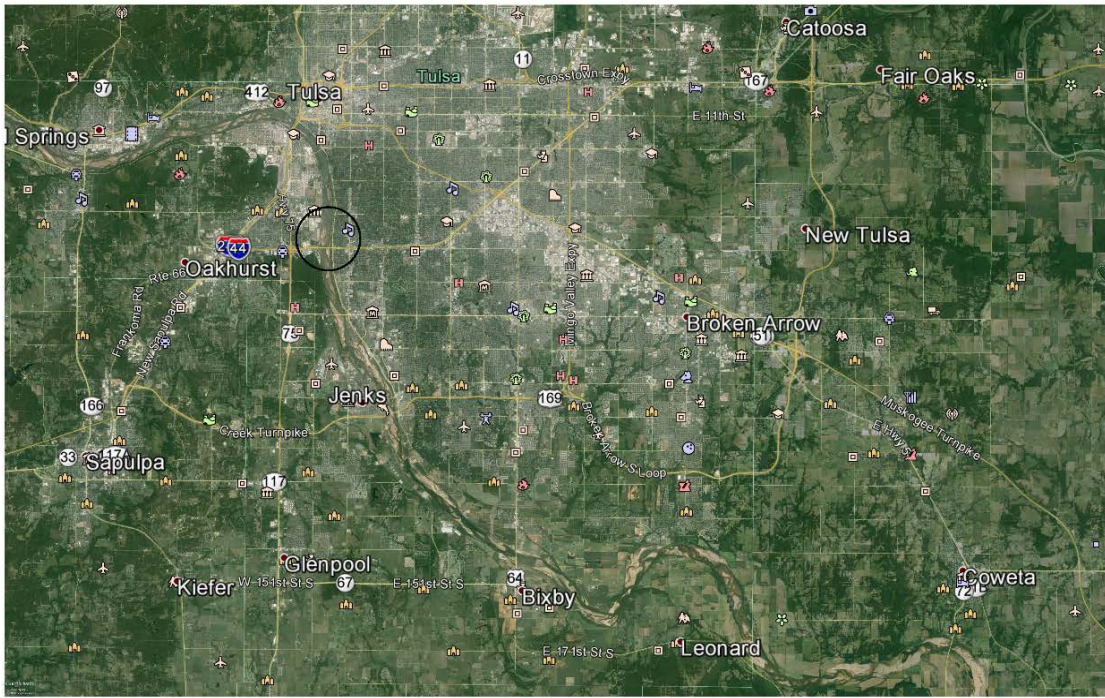
**I-44/Riverside Wing Deflectors + Rock Riffle + Riparian Plantings:** This alternative includes the design and construction of the rocked riffle and wing deflectors listed in the above alternative, with the addition of riparian type plantings. For this area, the riparian plantings are comprised of Red-Osier Dogwood trees and Brush Willows which have a minimum height of 3'- 4' and a minimum caliper of 1". It is calculated that this alternative will require approximately 11,100 plants across the creek's embankment in order to restore the native habitat for wildlife. Design drawings for the plantings and rock structures are shown in SK-7, SK-8, and SK-9 below.

**I-44/Riverside Wing Deflectors + Rock Riffle + Wetland Plantings:** This alternative includes the design and construction of the rocked riffle and wing deflectors listed in the above alternative, with the addition of wetland type plantings. For this area, the wetland plantings are comprised of ornamental grasses. It is calculated that this alternative will require approximately 9,000 plants across the creek's embankment in order to restore the native habitat for wildlife.

Design drawings for the plantings and rock structures are shown in SK-7, SK-8, and SK-9 below.

**I-44/Riverside Wing Deflectors + Rock Riffle+ Riparian Plantings + Wetland Plantings:** This alternative includes the design and construction of the rocked riffle and wing deflectors listed in the above alternative, with the addition of the riparian planting alternative and the wetland planting alternative. Design drawings for the plantings and rock structures are shown in SK-7, SK-8, and SK-9 below.

**Quantity Summary for I-44/Riverside:** The estimated quantities for this stage in design are 690 CY of 24" riprap for slack water side channels, 125 CY of 24" riprap and 37 CY of 6" bedding for the rock riffle. For plantings estimator should assume 9,000 wetland plantings, 11,000 riparian plantings, and 1.94 acres of invasive species control.



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**ARKANSAS RIVER CORRIDOR  
I-44/RIVERSIDE LOCATION**



DESIGNER: N/A  
SCALE: NOT TO SCALE

DATE: 08/16/2016  
DRAWING: SK-7







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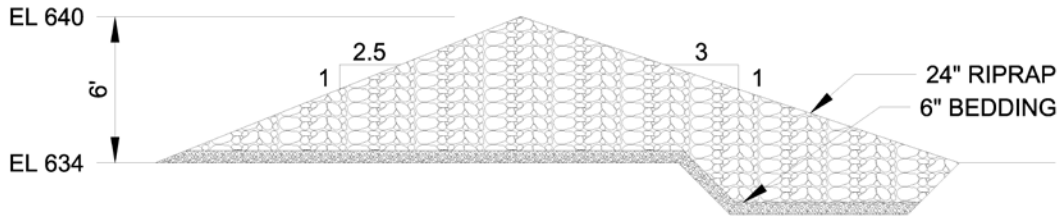
**ARKANSAS RIVER CORRIDOR  
I-44/RIVERSIDE LOCATION**



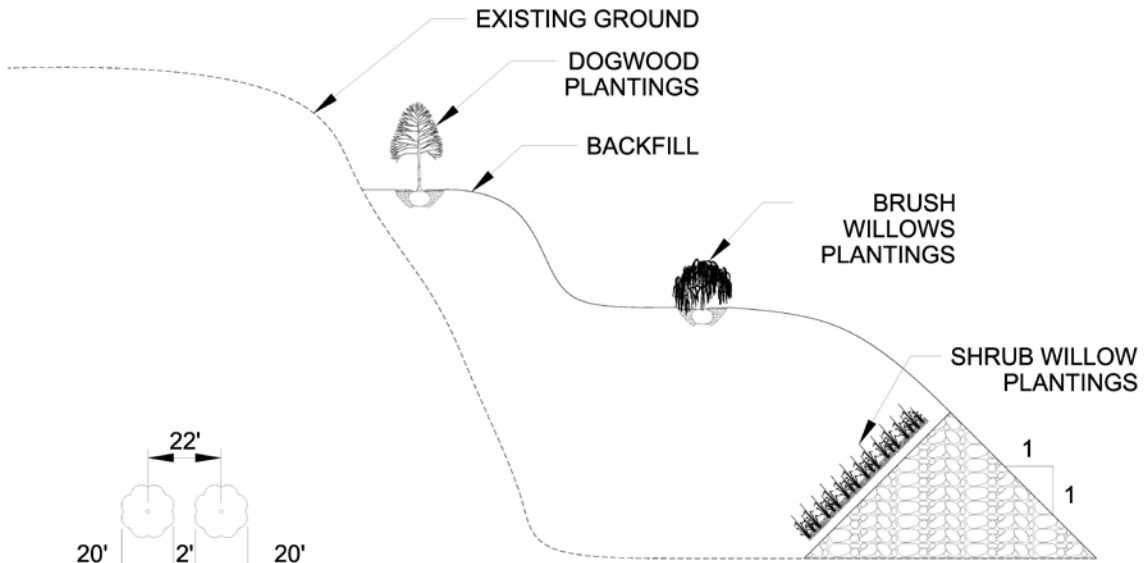
DESIGNER: N/A  
SCALE: NOT TO SCALE

DATE: 08/16/2016  
DRAWING: SK-8

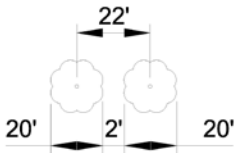




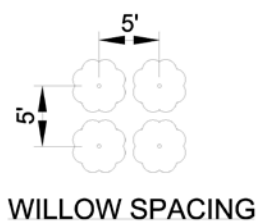
**ROCKED RIFFLE CROSS SECTION**



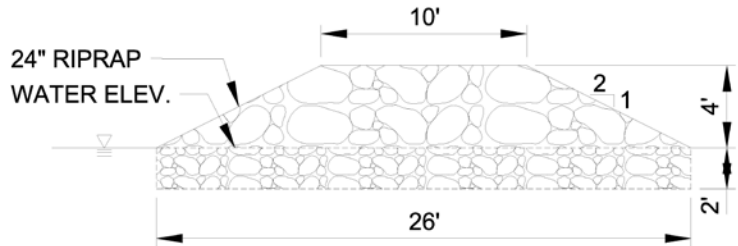
**DOGWOOD SPACING**



**ROCKED RIFFLE AND PLANTINGS SECTION**



**WILLOW SPACING**



**TYPICAL WING DEFLECTOR CROSS SECTION**

U.S. ARMY CORPS OF ENGINEERS, TULSA DISTRICT

**ARKANSAS RIVER CORRIDOR  
I-44/RIVERSIDE LOCATION**



DESIGNER: N/A  
SCALE: NOT TO SCALE

DATE: 08/16/2016  
DRAWING: SK-9



**PED Phase Actions:** During the PED phase following feasibility, a civil site survey will be performed from which plans will be developed in accordance with ER 1110-2-1150 to include alignments, control points, and bench marks. A physical security plan will be developed in coordination with the non-federal sponsor and in accordance with ER 1110-2-1150. Construction access points and traffic control requirements will be further developed utilizing project areas as defined in the Real Estate Appendix. Additional geotechnical investigation will be performed as described in the Geotechnical Appendix after which load case analysis can be performed to confirm the design assumptions that CH2M Hill made during concept design of the pool control structure.