

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 melanotos*) 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
Project No.
Design Stage

Sand Springs
386594
Schematic Design

Estimator:
Rev No. / Date:
Estimate Class:

Jones T
02 - 04/24/2014
Class 3

Detail Report

El'd 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	
SS500				Low Water Dam & Pedestrian Bridge											
	610			Low Water Dam											
	02.0			Concrete Work											
03-40				Cast-In-Place Concrete Work											
				Concrete Flying Walls @ Dam Ends											
				Concrete Flying Wall, rectangular, 10' high, 10' wide, 10' height	300.000' ft	-	-	-	4,961	-	-	4,961	4,961	4,961	
				Foam insipre, structural walls + 10' high, 10' wide	7,000.000' ft	1,190.9	53,159	9,454	-	-	9,454	1,190 JY	85,000	85,000	
				Foam insipre, wall backfill	210.000' ft	83.0	2,846	263	-	-	263	149 JY	3,109	3,109	
				Reinforcing in place, 14#10, 60' per pair	71,771.78' ft	-	-	38,889	15,556	-	-	0.73 JF	54,444	54,444	
				Concrete, ready mix, 4000 psi	1,000.000' ft	-	-	-	4,611	-	-	4,611	4,611	4,611	
				Astl Kit concrete waste, 4000 psi	19.44' cu	-	-	-	2,431	-	-	2,431	2,431	2,431	
				Piping, concrete, concrete pump, for structural wall + 2" thick	200.000' ft	201.7	11,200	-	-	-	-	20.03 JY	11,201	11,201	
				Patent, plug blocks	7,000.000' ft	105.3	4,832	141	-	-	-	0.83 JF	4,172	4,172	
				Skid-steer, 3000 lbs, 10' wide	1,000.000' ft	200.3	10,522	215	-	-	-	1.5 JF	10,522	10,522	
				Curing, membrane spray	7,000.000' ft	14.0	538	268	-	-	-	0.12 JF	311	311	
				Concrete Wing Walls @ Dam Ends	358.82' CY	1,843.7	33,125	100,273	20,222	-	-	203,866	203,866	203,866	
				Free Support @ Wing Walls for Pedestrian Bridge											
				Concrete, ready mix, 4000 psi, 10' wide	1,181.4' cu	-	-	-	1,410	-	-	1,410 JY	1,410	1,410	
				Foam insipre, columns, round, 10' dia	4,155.0' cu	919.9	41,656	7,684	-	-	-	0.81 JF	49,221	49,221	
				Reinforcing in place, 14#10, 60' per pair	29,530.0' ft	-	-	14,708	5,307	-	-	0.73 JF	30,075	30,075	
				Concrete, ready mix, 4000 psi	1,181.4' CY	-	-	14,708	-	-	-	25.03 JY	14,768	14,768	
				Add to concrete waste, 4000 psi	1,181.4' cu	-	-	738	-	-	-	1.24 JF	738	738	
				Piping, concrete, concrete pump	1,181.4' cu	89.8	3,602	-	-	-	-	28.93 JY	3,402	3,402	
				Stone, rock	5,110.35' cu	265.5	9,812	153	-	-	-	1.95 JF	9,961	9,961	
				Curing, membrane spray	5,110.35' cu	18.2	282	204	-	-	-	0.12 JF	597	597	
				Free Support @ Wing Walls for Pedestrian Bridge	1,181.14' CY	1,874.2	55,162	39,296	7,029	-	-	85,08 JY	100,783	142,771	
				Rock Bolts - 1/2" dia x 12' Standard											
				Rock bolts, upper half-tight, 1/2" dia, 12', ASTM A-108	140.00' ft	125.9	6,779	79,128	-	-	-	50,715 JY	86,091	130,033	
				Rock bolts, cut hole, 1/2" dia, 16' long, for 7/8" bolt	140.00' ft	167.0	21,879	-	-	-	-	266,111 JY	39,294	34,544	
				Rock Bolts - 1/2" dia x 16' Bonded	140.00' EA	632.8	25,058	79,920	-	-	-	846,356 JY	129,258	182,819	
				Rock Bolts - 3/8" dia x 12' Standard											
				Rock bolts, upper half-tight, 3/8" dia, 12', ASTM A-108	120.00' ft	121.3	5,943	87,128	-	-	-	76,912 JY	93,063	136,905	
				Rock bolts, cut hole, 3/8" dia, 16' long, for 2 1/2" bolt	120.00' ft	174.1	33,415	-	-	-	-	40,254 JY	59,124	85,330	
				Rock Bolts - 3/8" dia x 20' Bonded	120.00' EA	894.0	39,203	87,120	-	-	-	1,264,20 JY	152,987	221,894	
				Concrete Anchored Shoring											
				All grout, concrete, 10' wide by 10' high	111,296.00' ft	778.1	29,916	1,113	-	-	-	0.33 JF	31,029	31,029	
				Concrete, pumping, saturated at 10' wide by 10' high	2,600.00' cu	-	-	-	24,720	-	-	12,00 JY	24,720	24,720	
				Concrete, ready mix, 2000 psi	2,600.00' CY	-	-	2,616	2,308	-	-	1,05,03 JY	2,16,318	37,791	
				Piping, concrete, concrete pump	2,600.00' cu	1,549.0	59,126	-	-	-	-	28.83 JY	59,128	59,128	
				Concrete Grouting, concrete	2,090.00' cu	2,024.1	89,242	217,419	24,720	-	-	169,38 JY	351,028	480,409	
				Concrete Grouting Data											
				Concrete grouting, saturated, 10' structure price	45,820.74' cu	-	-	-	53,369	-	-	12,00 JY	552,369	61,132	
				Concrete, Casing	45,820.74' cu	-	-	-	145,311	-	-	7,43 JY	145,211	41,096	
				Water, 10' dia, 10' high, 10' wide	14,920.00' cu	1,549.3	54,467	80,113	-	-	-	7,24 JF	93,417	93,417	
				Water, 10' dia, 10' high, 10' wide	115,812.00' cu	154,93.3	1,561,142	145,018	-	-	-	74,81 JY	1,72,193	2,355,985	
				Water/tank, PVC, round, white/blast, 3/4" thick, 8' wide	2,14,000.00' ft	131.1	6,375	9,471	-	-	-	7,59 JF	15,043	22,003	
				Reinforcing in place, 14#10, 60', pre-drilled	4,602,374.00' ft	-	-	2,341,637	620,615	-	-	0.73 JF	2,222,152	4,048,814	
				Concrete, ready mix, 2000 psi	1,000.000' cu	-	-	-	5,715,447	-	-	7,65 JF	7,65,000	7,65,000	
				Add to concrete waste, 4000 psi	1,430.00' cu	-	-	5,715,447	-	-	-	1,02,93 JY	375,384	381,945	
				Piping, concrete, concrete pump	46,630.74' cu	46,630.7	1,767,534	-	-	-	-	364 JY	1,74,704	2,380,022	
				Finishing, fibers, meshing, trash finish	111,266.00' cu	7,419.7	323,359	2,225	-	-	-	2.91 JF	325,593	44,051	
				Curing, membranes, 10' wide by 10' high	1,111.00' cu	3,617	5,447	5,447	-	-	-	0.12 JF	5,447	5,447	
				Concrete Grouting Data	46,030.74' CY	100,374.0	4,227,245	8,661,048	1,916,124	-	-	333,77 JY	14,900,617	21,663,241	
				03-10 Cast-In-Place Concrete Work	48,897.77' CY	107,342.4	4,527,191	9,270,030	1,870,481	43,986	-	-	326,48 JY	15,817,617	22,990,630
				03-0 Concrete Work	48,897.77' CY	107,342.4	4,527,191	9,270,030	1,870,481	43,986	-	-	326,48 JY	15,817,617	22,990,630
31-0				Site Civil											
				31-10 Temporary Works											
				Porta-cam, crib	2,108.00' cu	24.9	-	-	15,000	-	-	15,000 JY	-	15,000	
				Porta-cam, inflation	2,500.00' ft	809.0	29,146	5,008	-	25,201	-	29,081 JY	-	59,021	
				Porta-cam, rental	24,000.00' cu	-	-	-	-	243,000	-	130,000 JY	24,000 JY	130,000	
				Porta-cam, rental	2,500.00' cu	-	-	-	-	-	12,644	-	12,644		
				Porta-cam, concrete	1,000.00' cu	24.2	-	-	13,000	-	-	13,000 JY	-	13,000	
				Bafl, ret, w/ comp, 300 HP dozer, 5'x10', common earth	31,376.00' cu	261.7	12,695	-	-	-	32,277	-	13,4 JY	44,211	82,071
				Excav, bulk rock removal, 3' x 5' x 10', hard rock	32,376.00' cu	263.7	11,526	-	-	-	30,952	-	12,3 JY	38,968	51,920
				Excav, excavator, 10' wide by 10' deep, 10' front end, 10' rear end	23,765.00' cu	263.3	18,006	-	-	-	20,542	-	3,78 JY	20,542	30,581
				Excav, excavator, 10' wide by 10' deep, 10' front end, 10' rear end	23,765.00' cu	263.3	18,006	-	-	-	20,542	-	3,78 JY	20,542	30,581

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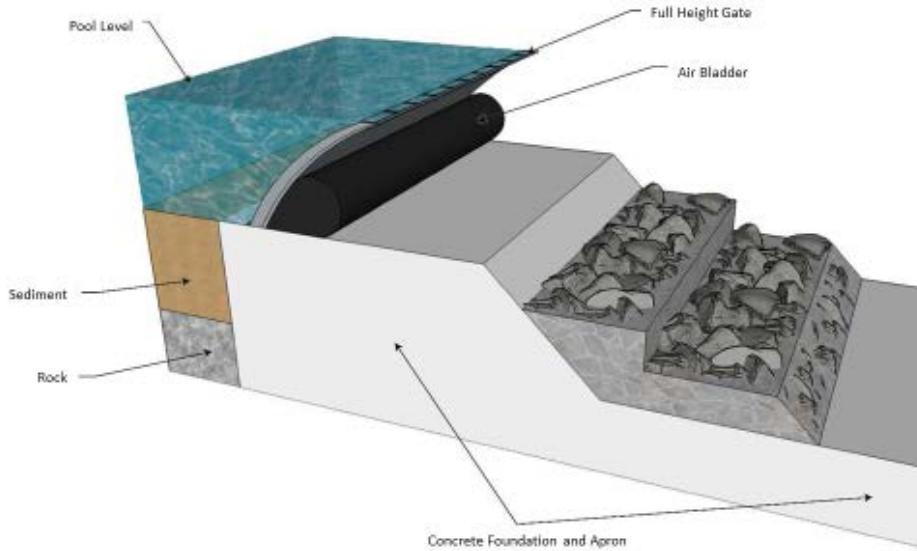
Project:
Project No.:
Design Stage:

Sand Springs
30594
Schematic Design

Estimator:
Rev No. / Date:
Estimate Class:

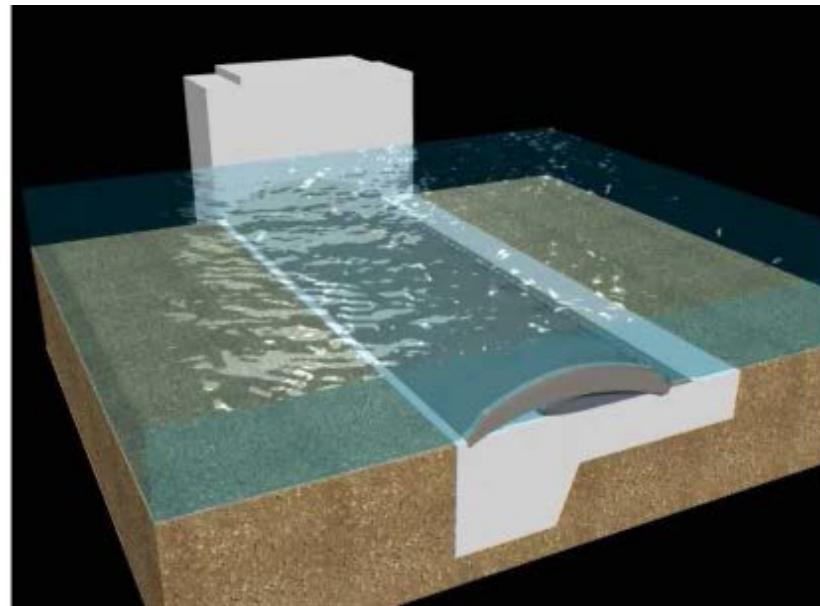
Detail Report

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
				Prestressed Bridge @ Low Cost Crossing:										
				Fence and concrete piers, concrete in place, no reinforcing, beams, include shoring	150.00' LF	1,440.0	67,204	64,008	-	10,962	-	308.13 /LF	148,278	211,441
				Prestressed Concrete Beams (Type 14D)	3,816.00' LF	-	-	-	1,611,370	-	-	370.03 /LF	1,615,593	2,084,137
				Prestressed Concrete Deck Panels	39,160.00' LF	-	-	-	51,040	-	-	140.93 /LF	5,144.49	78,341
				Prestressed Bridge @ Low Cost Crossing	30,000.00' LF	4,289.7	226,723	271,221	1,946,160	18,190	-	46.24 /LF	2,462,218	3,614,231
				32-04 Fabricated Bridges	1.00 EA	4,289.7	226,723	271,221	1,946,160	18,190	-	2,462,217.30 /EA	2,462,218	3,614,231
				32-05 Exterior Improvements	1.00 LS	4,289.7	226,723	271,221	1,946,160	18,190	-	2,462,217.30 /LS	2,462,218	3,614,231
				020 Pedestrian Bridges	1.00 EA	4,289.7	226,723	271,221	1,946,160	18,190	-	2,462,217.30 /EA	2,462,218	3,614,231
				080 Structures										
				Special Construction										
				19-34 Fabricated Engineered Structures										
				25-40 Dam Control Building										
				32-04 Dam Control Building (A-Knowles)	1.00 EA	-	-	-	80,000	-	-	80,000.00 /EA	80,000	118,201
				25-40 Dam Control Building	1.00 EA	-	-	-	80,000	-	-	80,000.00 /EA	80,000	118,201
				12-5 Standard Engineered Structures	1.00 EA	-	-	-	80,000	-	-	80,000.00 /EA	80,000	118,201
				13-0 Special Construction	1.00 LS	-	-	-	80,000	-	-	80,000.00 /LS	80,000	118,201
				080 Structures	1.00 EA	-	-	-	80,000	-	-	80,000.00 /EA	80,000	118,201
				080 Retaining Walls										
				Site Civil										
				31-49 Earthworks, Site										
				31-50 Earthworks, Site										
				31-50-1 Heavy Civil Excavation										
				31-50-1A Heavy Haulers & Operators	2.00 HHR	2.8	90	53	-	134	-	137.93 /HHR	376	382
				Dust Control Operators	10.00 HFL	16.0	701	-	-	0.07	-	151.03 /HFL	1,518	2,123
				Gloves & Tools for Equipment Lube Oil, Extended Range	1.00 HFL	1.8	47	11	-	85	-	117.17 /HFL	113	168
				Excavator, backhoe, motorized, 1.7 cu yd, 10 ft 6 in 20 ft C / 100 ft 6 in	4,000.00 DOL	38.0	1,374	-	-	1,539	-	1.23 /DOL	4,912	6,948
				Excavator, hydraulic, motorized, 1.7 cu yd, 10 ft 6 in 20 ft C / 100 ft 6 in	4,000.00 DOL	44.0	1,669	-	-	12,033	-	3.43 /DOL	13,702	17,056
				Hauler, dump truck, rear dump, 10 cu yd, 10 ft 6 in 20 ft C / 100 ft 6 in	4,000.00 CY	80.7	3,675	64	-	16,800	-	6.13 /CY	20,887	29,198
				Hauler, dump truck, rear dump, 10 cu yd, 10 ft 6 in 20 ft C / 100 ft 6 in	4,000.00 CY	92.7	3,675	64	-	16,800	-	20,877.40 /LS	20,877	29,198
				31-50-2 Site Civil	1.00 LS	92.7	3,675	64	-	16,598	-	20,877.40 /LS	20,877	29,198
				31-50-3 Exterior Improvements										
				32-32 Retaining Walls										
				32-32-1 Retaining Wall - 5 ea Wall 10' Ht.										
				Gold beam, 4 leg, no header, 10 ft 6 in 10 ft 6 in 20 ft 2 line of brace	2,000.00' LF	540.0	25,407	30,200	-	17,364	-	96.93 /LF	23,051	184,064
				Golden beam, 4 leg, no back header, 10 ft 6 in 10 ft 6 in 20 ft	30.00' ea	720.0	31,914	16,658	-	2,017	-	1,666.05 /ea	50,991	76,099
				Structural concrete piers, free standing wall, 3000 psi, 12" thick x 14" high, includes form & seal, reinforcing steel, core rebar, placing and finishing	74.07' ea	376.0	17,806	11,258	-	1,048	-	406.58 /ea	30,114	12,451
				Retaining Wall - 5 ea Wall 10' Ht.	200.00 LF	1,900.0	70,003	50,199	-	20,430	-	728.73 /LF	150,744	219,199
				32-32-2 Retaining Wall - 5 ea Wall 20' Ht.										
				Gold beam, 4 leg, no header, 10 ft 6 in 10 ft 6 in 20 ft 2 line of brace	8,000.00' LF	1,066.3	69,676	40,453	-	34,727	-	36.63 /LF	14,102	215,211
				Golden beam, 4 leg, no back header, 10 ft 6 in 10 ft 6 in 20 ft	910.00' ea	770.0	37,474	16,465	-	2,017	-	1,666.05 /ea	10,991	11,981
				Structural concrete piers, free standing wall, 3000 psi, 12" thick x 14" high, includes form & seal, reinforcing steel, core rebar, placing and finishing	1,481.00' LF	740.0	35,810	22,018	-	2,098	-	416.55 /LF	62,231	14,903
				Retaining Wall - 5 ea Wall 20' Ht.	220.00 LF	2,842.0	110,803	88,889	-	38,843	-	1,294.82 /LF	288,918	368,226
				32-32-3 Retaining Walls	400.00 LF	4,170.0	193,711	167,677	-	59,275	-	1,024.85 /LF	419,662	682,334
				32-32-4 Exterior Improvements	1.00 LS	4,170.0	193,711	167,677	-	59,275	-	450,681.53 /LS	419,662	682,334
				080 Retaining Walls	1,000.00 LF	4,240.0	197,693	167,741	-	76,862	-	431.19 /LF	431,199	612,619
				110 Utilities										
				110-1 Electrical Work										
				26-40 Site Electrical										
				Site Lighting										
				Site Lighting - Pile driver bridge	1.00 LF	-	-	-	173,000	-	-	173,000.00 /LF	170,000	211,178
				Site Lighting	1.00 LS	-	-	-	170,000	-	-	170,000.00 /LS	170,000	211,178
				25-10 Site Electrical	1.00 LS	-	-	-	170,000	-	-	170,000.00 /LS	170,000	211,178
				25-20 Site Electrical Work	1.00 LS	-	-	-	170,000	-	-	170,000.00 /LS	170,000	211,178
				110 Utilities	1.00 LS	-	-	-	170,000	-	-	170,000.00 /LS	170,000	211,178
				S\$60 Low Water Dam & Pedestrian Bridge	1,908.00 LF	186,542.7	7,018,445	12,453,269	10,470,605	1,619,892	-	15,542.03 /LF	31,562,201	45,540,840



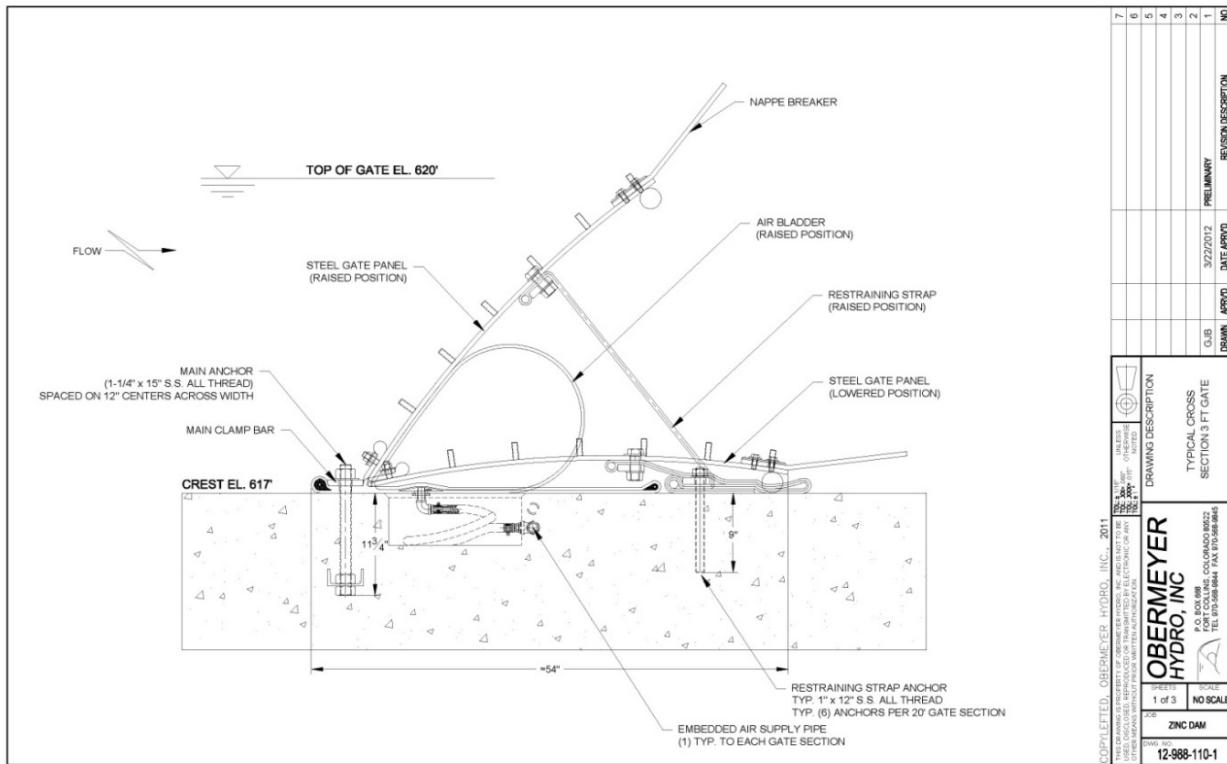
Pool Control Structure Concept Design

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

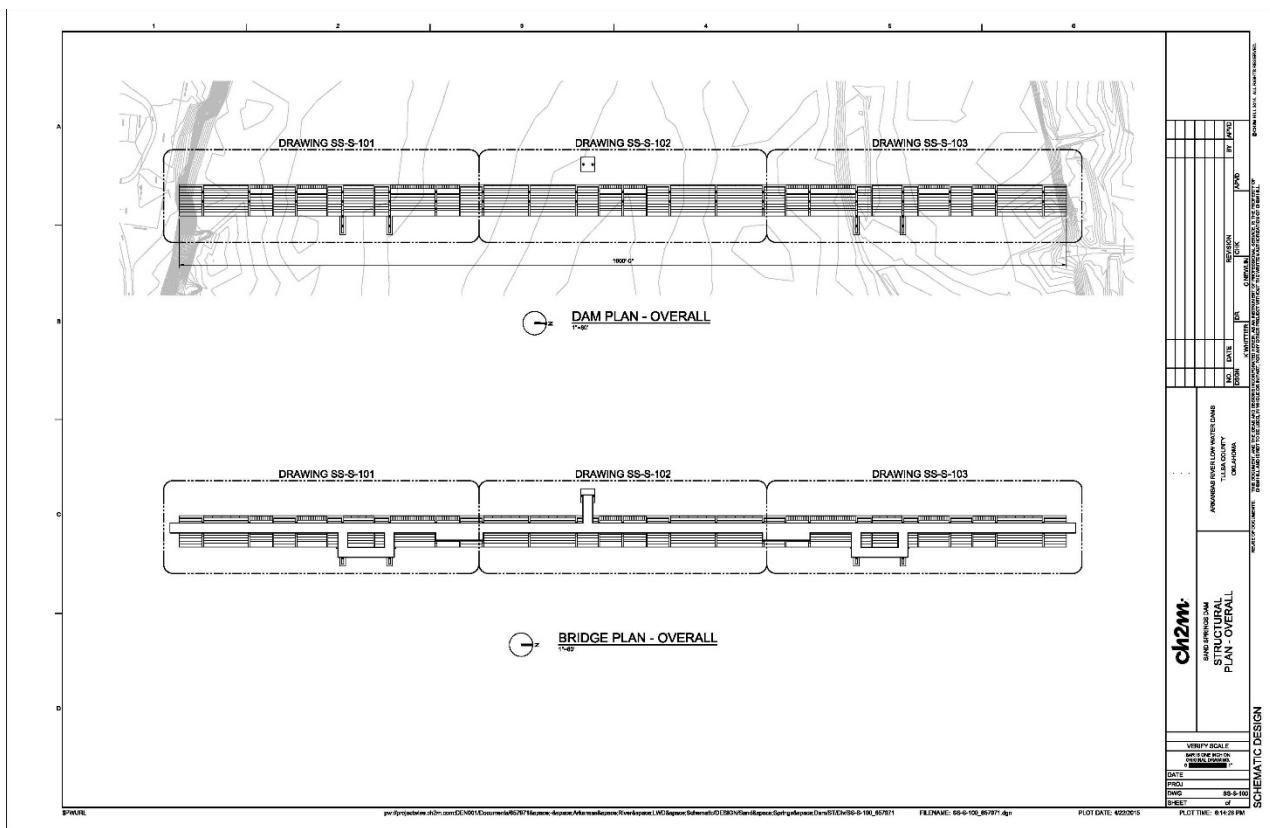


Pool Control Structure Concept Design

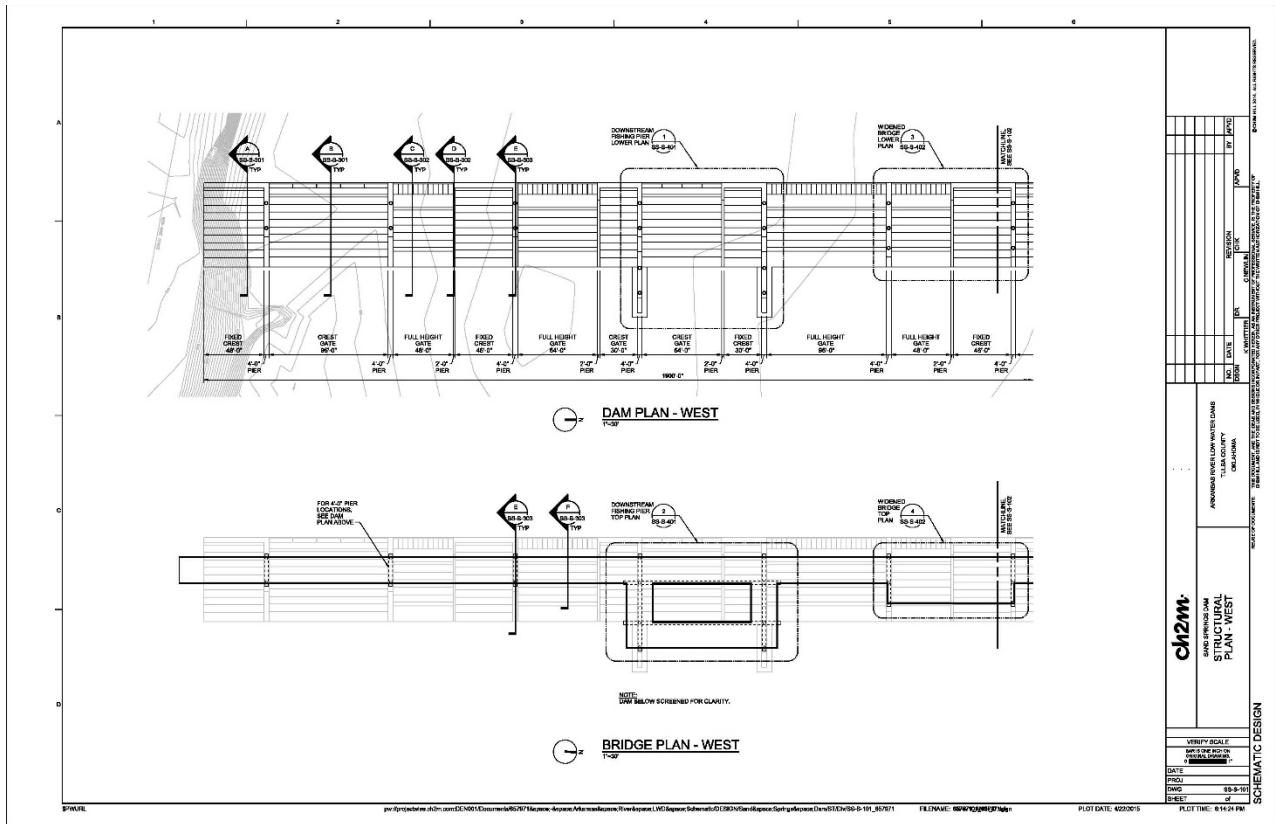
Note that the above image depicts the full height gates in the down position which will allow for unregulated river flow and unobstructed fish/egg/sediment passage during the monsoon season and associated flood pool releases.



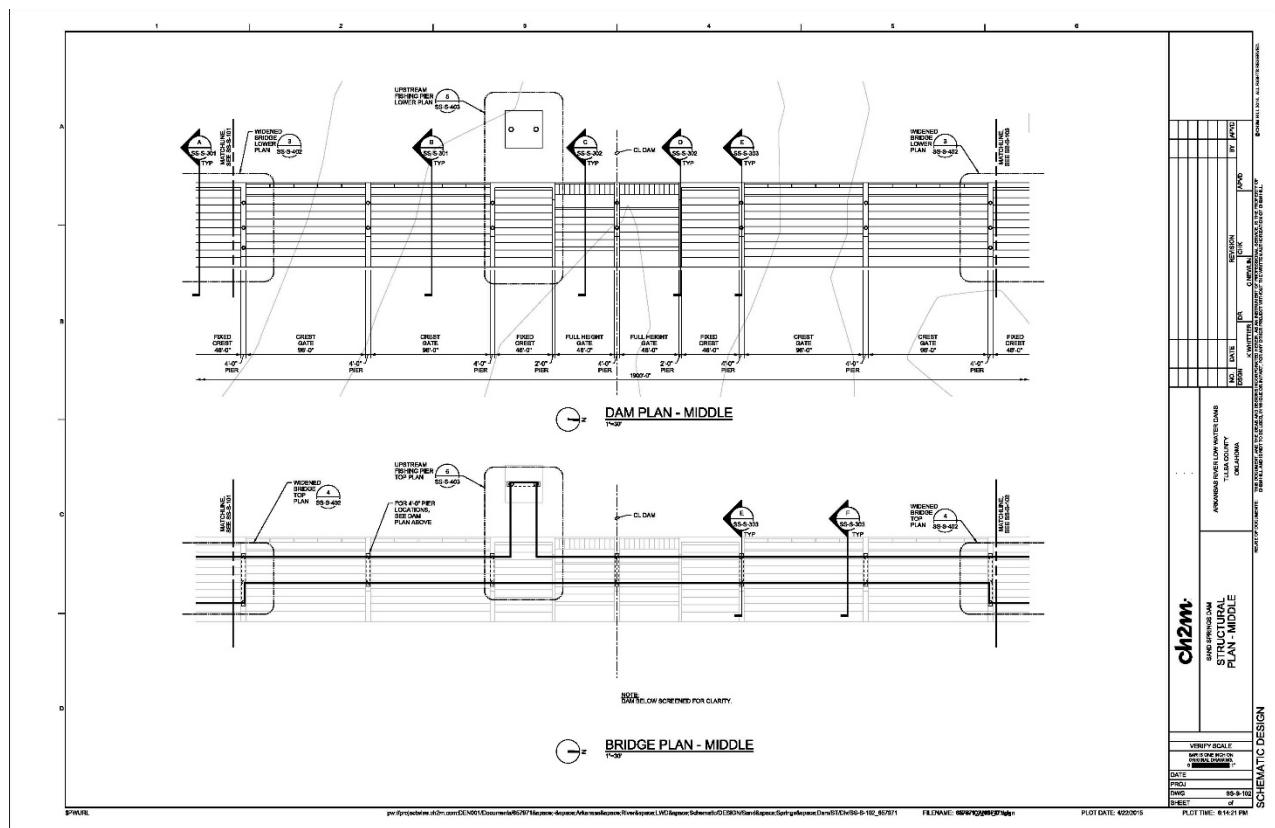
Note that the above is a representative image of an Obermeyer gate. During the Design Phase of the project the gates will be adapted and designed for use at the project location identified in this study.



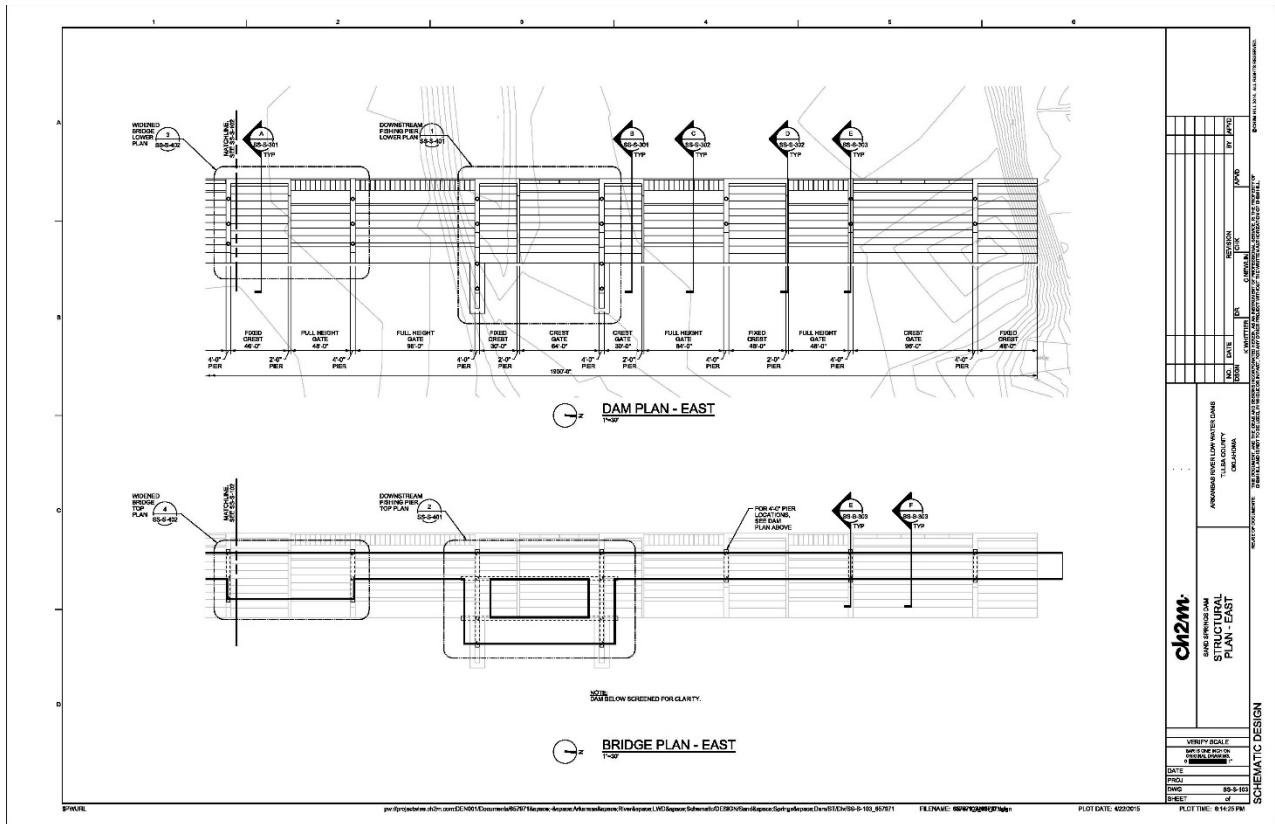
Note that the above is a conceptual design drawing. Final design will ensure correct dimensions and elevations for the project location identified in this study.



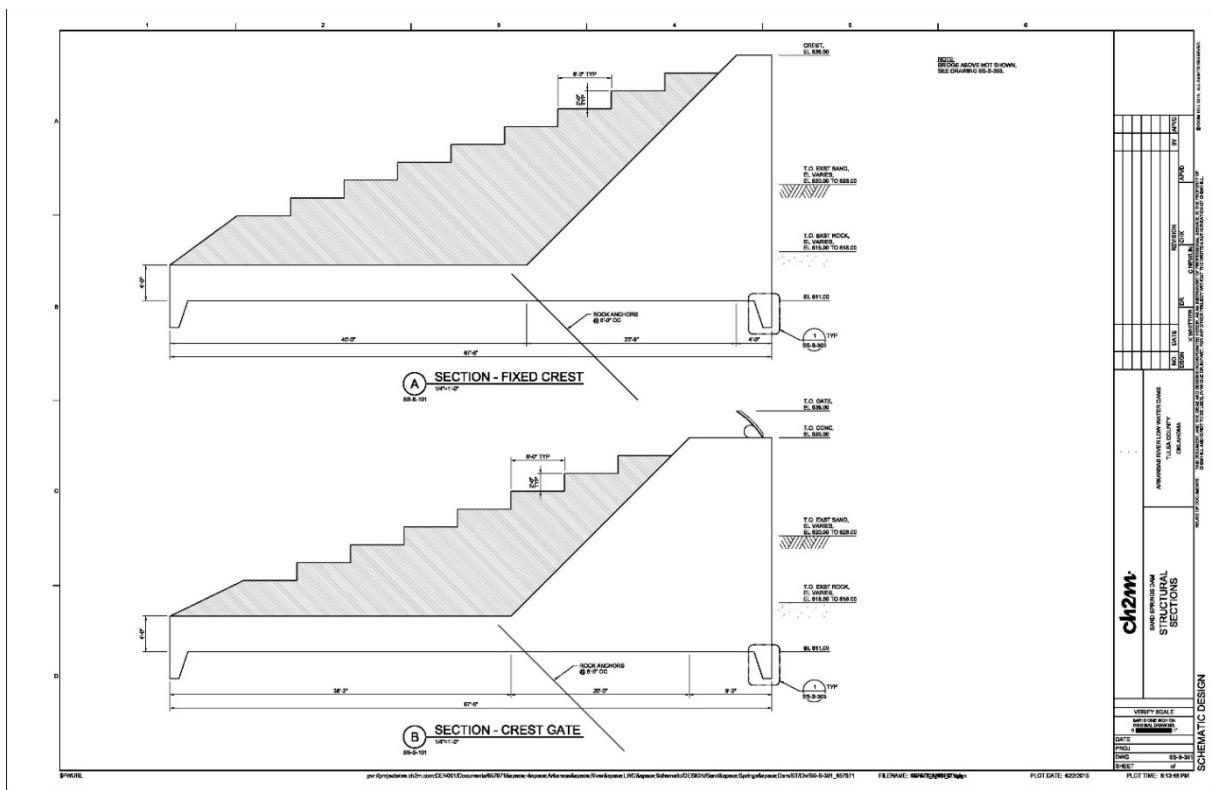
Note that the above is a conceptual design drawing. Final design will ensure correct dimensions and elevations for the project location identified in this study.



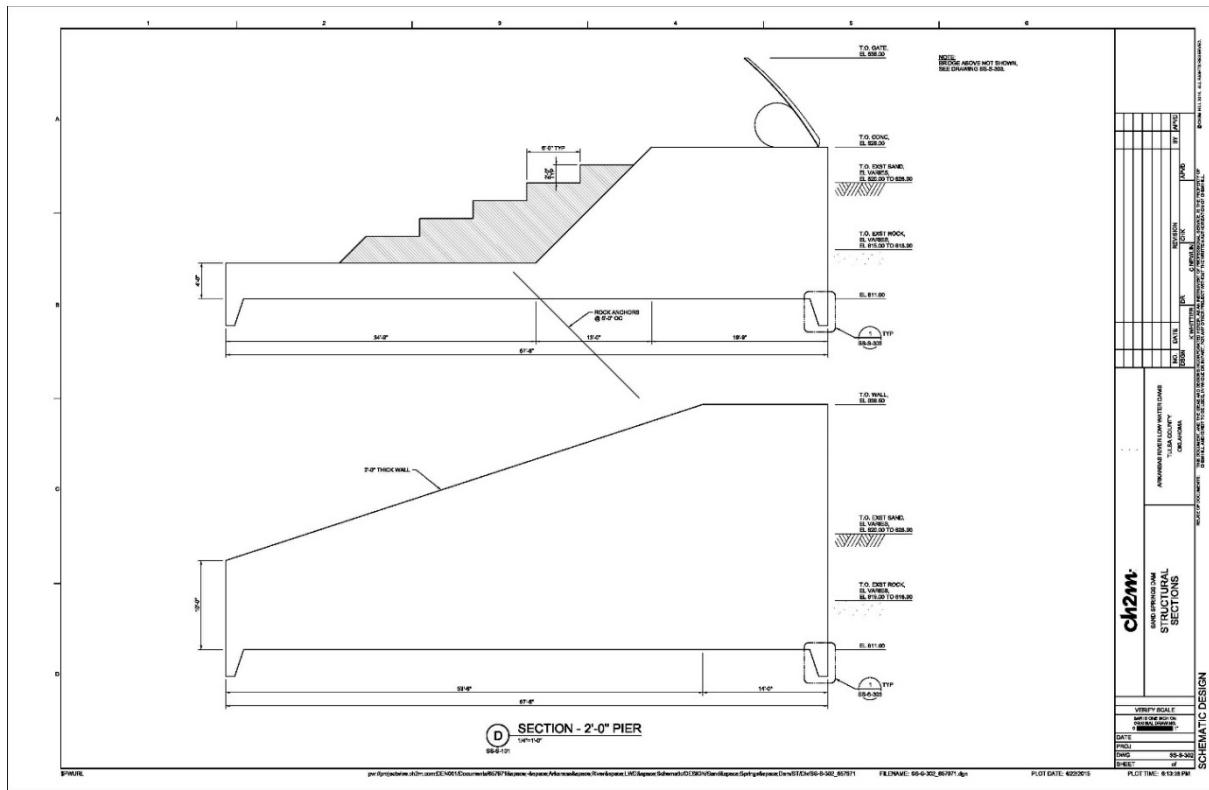
Note that the above is a conceptual design drawing. Final design will ensure correct dimensions and elevations for the project location identified in this study.



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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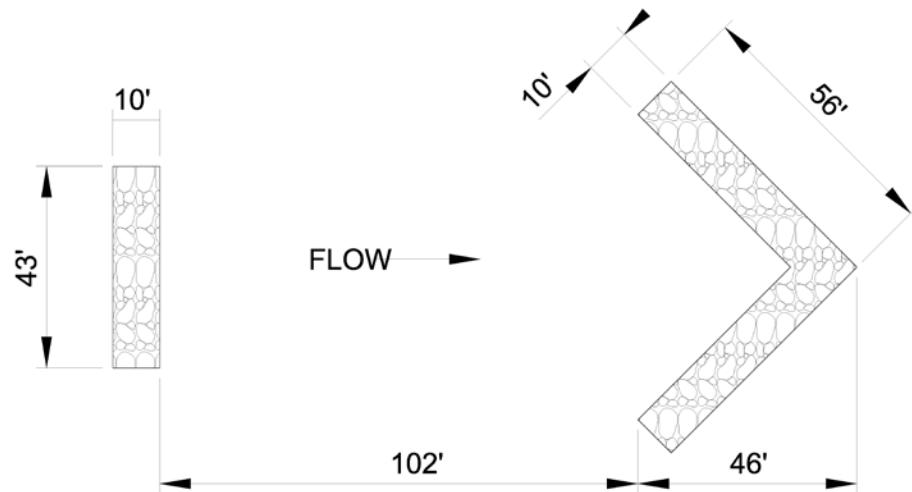


Note that the above is a conceptual design drawing. Final design will ensure correct dimensions and elevations for the project location identified in this study.

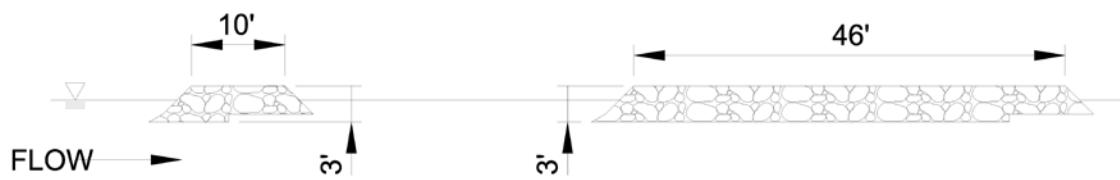
Least Tern Island: In 2003, the Oklahoma State University Biosystems Engineering Senior Design Team was selected by the U.S. Army Corps of Engineers (USACE) Tulsa District to conduct an analysis for the design of a least tern nesting habitat and the optimal location along the Arkansas River for implementation. 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. 145th E. Ave. and south of E. 131st 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.

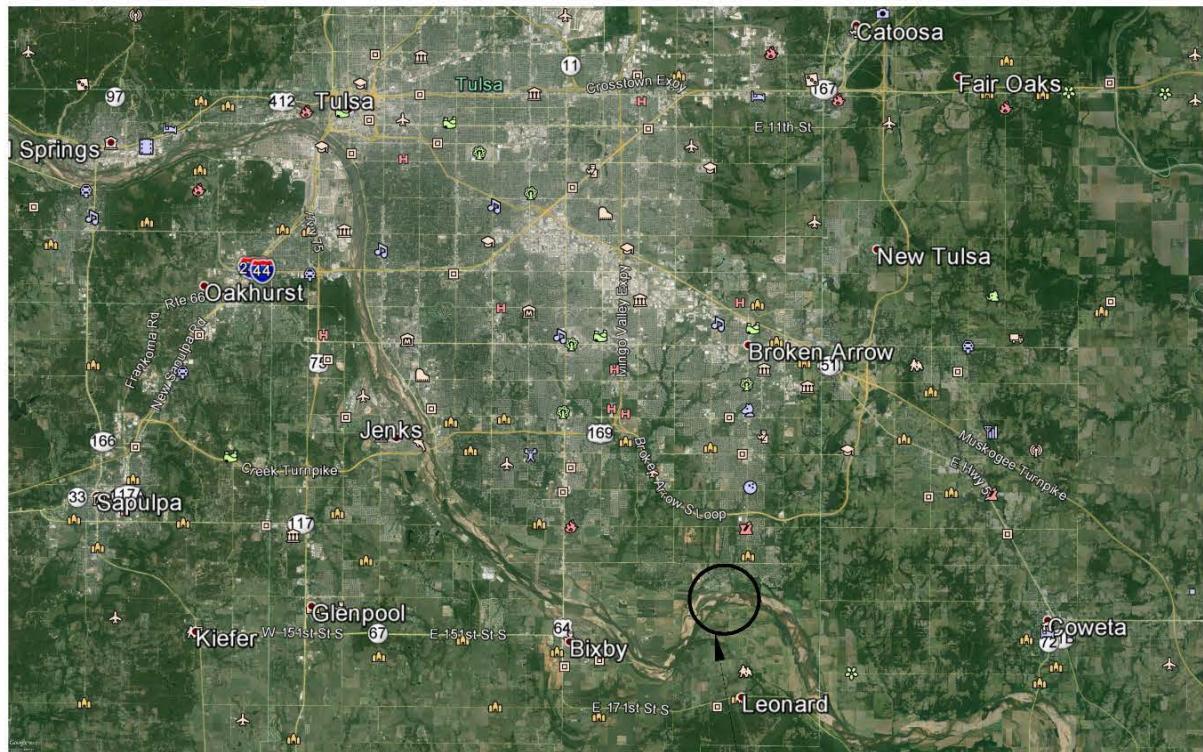


LEAST TERN ISLAND PLAN

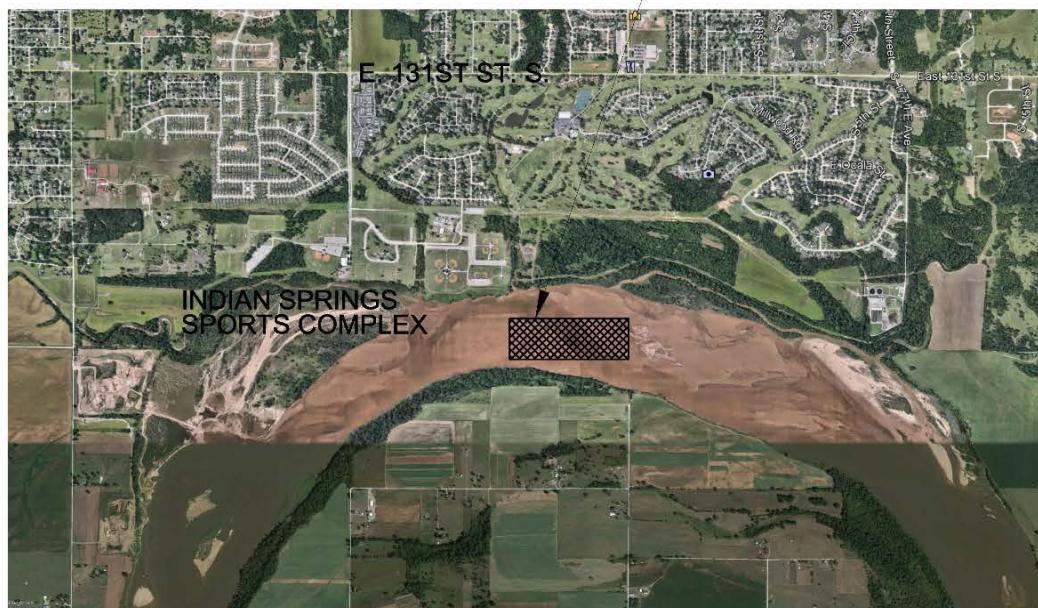


LEAST TERN ISLAND PROFILE 30" DIAM. RIP RAP

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

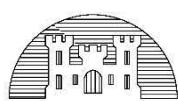


LEAST TERN
ISLAND LOCATION



U.S. ARMY CORPS OF ENGINEERS, TULSA DISTRICT

**ARKANSAS RIVER CORRIDOR
LEAST TERN ISLAND CONCEPT**



DESIGNER: N/A	DATE: 06/21/2017
SCALE: NOT TO SCALE	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.

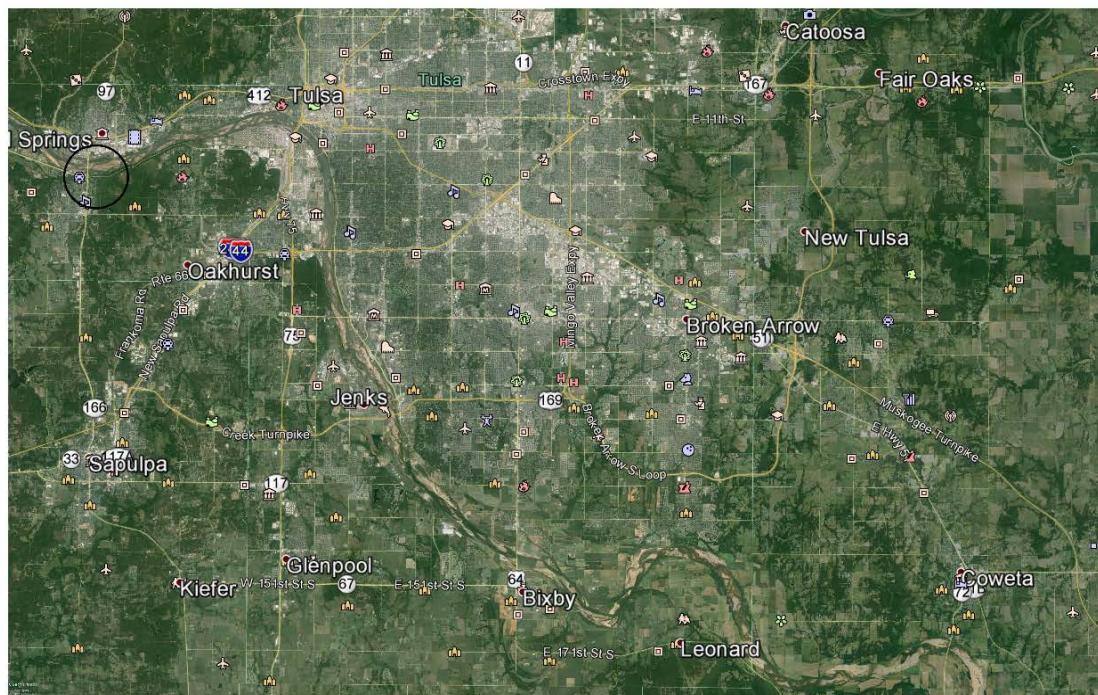
Quantity Summary for Prattville Creek: The estimated quantities for this stage in design are 4,640 CY of soil, 44 CY of 6" bedding stone, 383 CY of 24" riprap and 1,160 CY of 12" riprap. For plantings estimator should assume 6,960 wetland plantings (rushes, reeds, bulrushes), 15,600 riparian plantings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

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

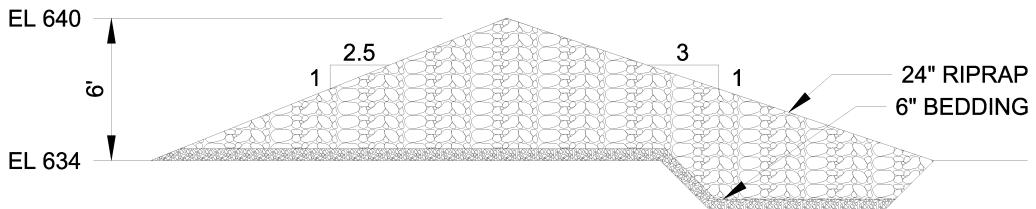
Prattville Creek Rocked Riffle and Riprap: Prattville Creek is located east of Highway 97 on the south bank of the Arkansas River in Sand Springs, Oklahoma. The ground elevation is at approximately 634 feet with a mouth width of approximately 80' (according to Google Earth). This alternative includes 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.

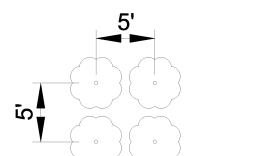
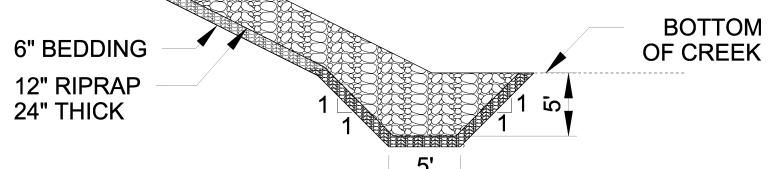
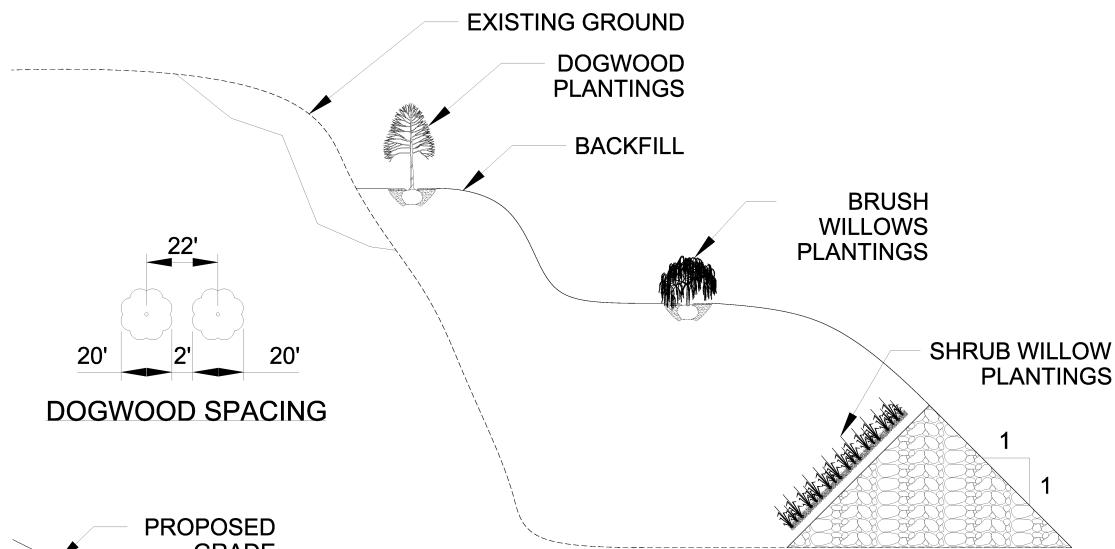
Prattville Creek Rock Riffle + Riparian Plantings + Wetland Plantings: This alternative includes the design and construction of the rocked riffle and riprap listed in the above alternative, with the addition of the riparian planting alternative and the wetland planting alternative. Design drawings for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



U.S. ARMY CORPS OF ENGINEERS, TULSA DISTRICT	
	ARKANSAS RIVER CORRIDOR PRATTVILLE CREEK
DESIGNER: N/A	DATE: 08/16/2016
SCALE: NOT TO SCALE	DRAWING: SK-5



ROCKED RIFFLE CROSS SECTION



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 1/5th 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.

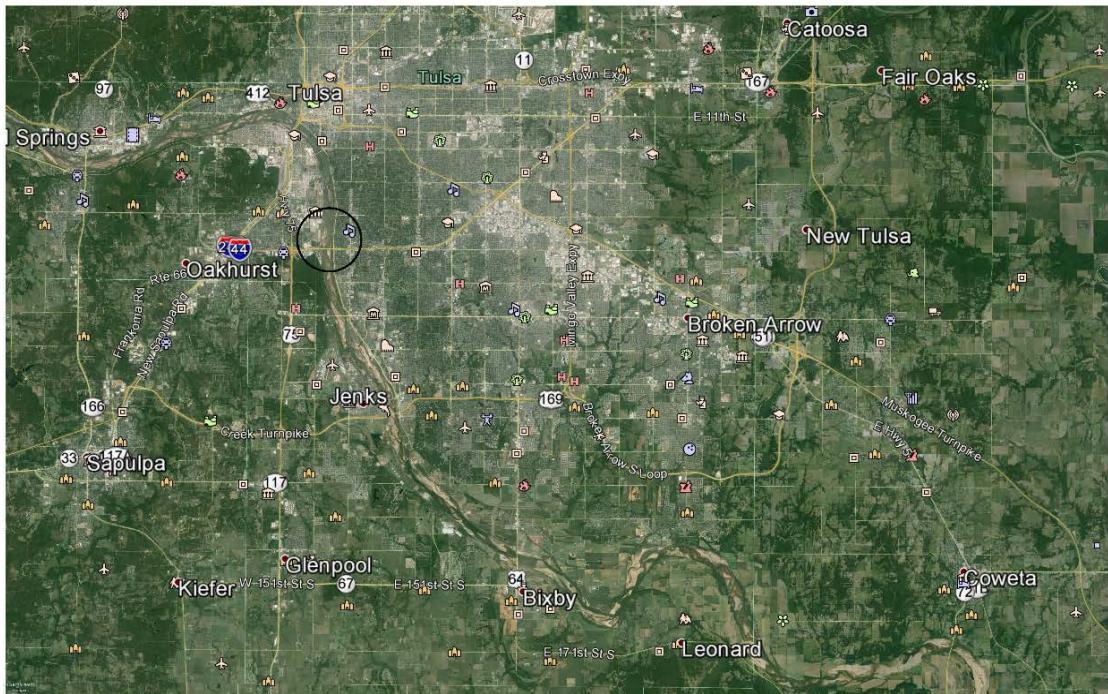
I-44/Riverside Wing Deflectors + Rock Riffle + Riparian Plantings: This alternative includes the design and construction of the rocked riffle and wing deflectors listed in the above alternative, with the addition of riparian type plantings. For this area, the riparian plantings are comprised of Red-Osier 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.

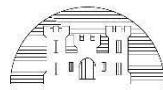
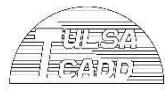


U.S. ARMY CORPS OF ENGINEERS, TULSA DISTRICT	
ARKANSAS RIVER CORRIDOR I-44/RIVERSIDE LOCATION	
DESIGNER: N/A	DATE: 08/16/2016
SCALE: NOT TO SCALE	DRAWING: SK-7



U.S. ARMY CORPS OF ENGINEERS, TULSA DISTRICT

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

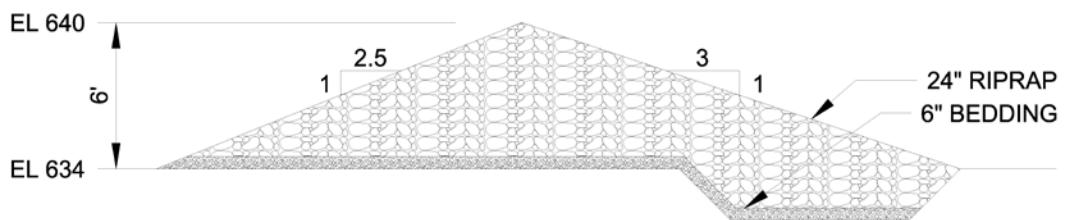


DESIGNER: N/A

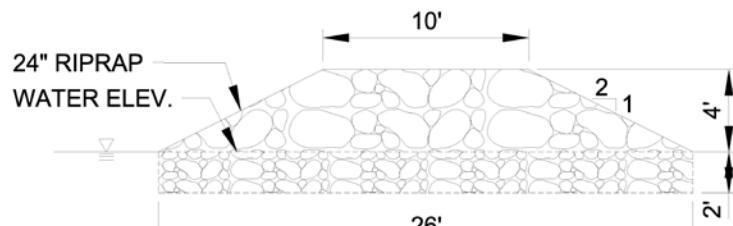
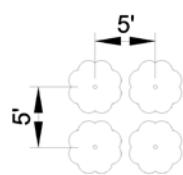
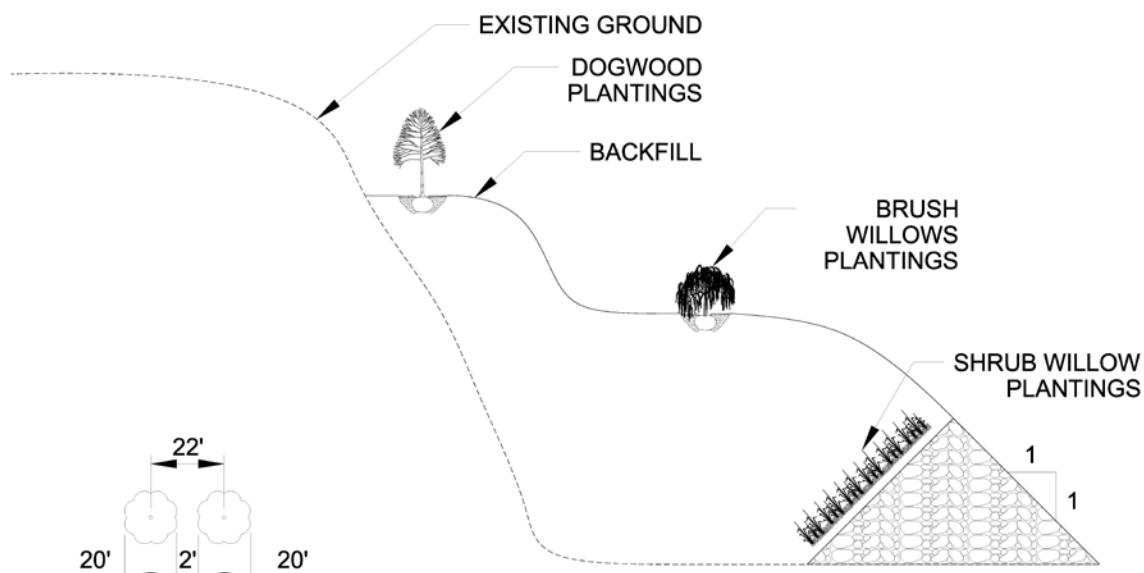
DATE: 08/16/2016

SCALE: NOT TO SCALE

DRAWING: SK-8



ROCKED RIFFLE 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.