ARKANSAS RIVER AND TRIBUTARIES
ARKANSAS AND OKLAHOMA

LOCK AND DAM NO. 9

ARKANSAS RIVER, ARKANSAS

SUPPLEMENT NO. 2

TO

DESIGN MEMORANDUM NO. 1, GENERAL FISH AND WILDLIFE FACILITIES AT HOLLA BEND NATIONAL WILDLIFE REFUGE

U. S. ARMY ENGINEER DISTRICT, LITTLE ROCK
CORPS OF ENGINEERS
LITTLE ROCK, ARKANSAS
NOVEMBER 1968

SWLED-PD (SWLGW-5, 5 Mar 65) 10th Ind
SUBJECT: Design Memorandum No. 1, General, Lock and Dam No. 9, Arkansas River and Tributaries, Arkansas and Oklahoma

DA, Little Rock District, Corps of Engineers, P. O. Box 867, Little Rock, Arkansas 72203 23 Oct 69

TO: Division Engineer, Southwestern

1. In compliance with instructions in subparagraph b of the 9th Indorsement, the following information concerning further coordination with the U. S. Fish and Wildlife Service is furnished.

2. Copies of preliminary plans for the closure structure (Plates 1A, 2, and 3 of Supplement No. 2) were furnished to the U. S. Fish and Wildlife Service for comment in March 1969. In April 1969 the Regional Director of the U. S. Fish and Wildlife Service, Atlanta, Georgia, stated that the plans for the proposed closure structure will meet the needs of his agency as designed. After receipt of this information, a representative of the Fish and Wildlife Service was advised that the plan for the structure was developed to mitigate damages without any consideration of functional improvements that might be justified. He was also advised that the authority of the Chief of Engineers permits the inclusion of appropriate additions and modifications for improvement of fish and wildlife resources that can be justified. After consideration of these possibilities by the Fish and Wildlife Service, this office was advised that the plans furnished in March are satisfactory.

3. In view of the decision of the Fish and Wildlife Service, this office is proceeding with the preparation of the plans and specifications for the closure structure at the Holla Bend National Wildlife Refuge on the basis of the design presented in Supplement No. 2 to the subject design memorandum.

FOR THE DISTRICT ENGINEER:

E. F. Rutt

E. F. RUTT
Chief, Engineering Division

SWDED-T (SWLGW-5, 5 Mar 65) 9th Ind
SUBJECT: Design Memorandum No. 1, General, Lock and Dam No. 9, Arkansas River and Tributaries, Arkansas and Oklahoma

DA, Southwestern Division, Corps of Engineers, 1114 Commerce Street, Dallas, Texas 75202 4 Mar 69

TO: District Engineer, Little Rock

For necessary action in accordance with the following comments:

a. Par 2 of the 8th Ind. When you submit plans and specifications, furnish the information necessary for us to approve the design of the riprap.

b. Par 4 of the 8th Ind. As soon as practicable, furnish the results of your further study and coordination with the Fish & Wildlife Service. Any proposed changes in design should be submitted for review.

FOR THE DIVISION ENGINEER:

ASA V. SHANNON
Chief, Engineering Division

Copy furn:
OCE (ENGCW-EZ) 10 cy

ENGCW-EZ (SWLGW-5, 5 Mar 65) 8th Ind
SUBJECT: Design Memorandum No. 1, General, Lock and Dam No. 9, Arkansas River and Tributaries, Arkansas and Oklahoma

DA, Office of the Chief of Engineers, Washington, D. C. 20315 3 February 1969

TO: Division Engineer, Southwestern

1. Supplement No. 2 is approved, subject to the following comments.

2. Paragraph 4.07a and 5-03c. Sufficient information as to the hydraulic forces on the proposed riprap and the riprap characteristics such as specific weight, shape, durability, and gradation limits is not furnished on which to base a judgment as to the adequacy of the design. As the cost of riprap is nearly one-third of the total construction cost and the integrity of the project depends on its ability to resist the hydraulic forces, this matter should be presented in sufficient detail to allow an independent review of the design. The Division Engineer should assure himself of the adequacy of the riprap design during review of the plans and specifications and that future design memorandums include more detailed presentations of the riprap design.

3. Paragraph 4-10b and Plate 4. The proposed top grade of the riverside cofferdam at elevation 298 feet msl is stated to protect the work area against a flow of 150,000 cfs with a freeboard of 0.5 feet. However, the rating curve shown on plate 4 for the Arkansas River at river mile 241, which is adjacent to the cofferdam, indicates that a discharge of 150,000 cfs would produce a water surface elevation at about 299.2 feet msl. This apparent discrepancy should be clarified.

4. As presented, the supplement plan has been developed for the mitigation of project detrimental effects upon the Holla Bend National Wildlife Refuge without any mentioned consideration for the functional improvement of the Refuge. While serving to mitigate project damage, the embankment dam and weir will be a project structure. Under authority of Section 2c of the Fish and Wildlife Coordination Act (P.L. 85-624), additions to and modifications of project structures and operations can be provided at project expense for the development or improvement of wildlife resources to the extent justifiable. Based upon experience with similar situations at other projects, wildlife area management agencies usually desire that a controlled drawdown capability be incorporated in their subimpoundments and pools, especially those used by waterfowl. It is unusual that no such capability has been discussed in this presentation. Accordingly, the Division Engineer should ascertain whether additions and modifications for the improvement of the fish and wildlife resource (e.g. minor raise in weir and embankment height, addition of controlled drawdown capability) are justifiable or are

ENGCW-EZ (SWLGW-5, 5 Mar 65) 8th Ind 3 February 1969
SUBJECT: Design Memorandum No. 1, General, Lock and Dam No. 9, Arkansas River and Tributaries, Arkansas and Oklahoma

desired by the Regional Director of the U. S. Fish and Wildlife Service. Appropriate revision or amendment of the supplement, to incorporate Service-requested minor additions and modifications deemed justifiable by the Corps, may be approved by the Division Engineer. Project funds may not be used to acquire any lands in connection with such additions and modifications.

FOR THE CHIEF OF ENGINEERS:

for Herman B. Willis
WENDELL E. JOHNSON
Chief, Engineering Division
Civil Works

wd all incl

SWDED-T (SWLCW-5, 5 Mar 65) 7th Ind
SUBJECT: Design Memorandum No. 1, General, Lock and Dam No. 9, Arkansas River and Tributaries, Arkansas and Oklahoma

DA, Southwestern Division, Corps of Engineers, 1114 Commerce Street, Dallas, Texas 75202 18 December 1968

TO: Chief of Engineers

Recommend approval.

FOR THE DIVISION ENGINEER:

I. M. RICE
Colonel, CE
Deputy Division Engineer

1 Incl
wd 5 cys

Copies furnished:
District Engineer
Little Rock District

SWLED-PA (SWLGW-5, 5 Mar 65) 6th Ind
SUBJECT: Design Memorandum No. 1, General, Lock and Dam No. 9, Arkansas River and Tributaries, Arkansas and Oklahoma

DA, Little Rock District, Corps of Engineers, P. O. Box 867, Little Rock, Arkansas 72203 27 November 1968

TO: Division Engineer, Southwestern

1. Reference is made to ER 1165-2-104, Responsibilities of the Corps of Engineers for the Preservation and Improvements of the Fish and Wildlife Resource, dated 19 January 1968.

2. In compliance with the above reference, and paragraph d of the 2d Ind., Supplement No. 2 concerning the development of fish and wildlife facilities at the Holla Bend National Wildlife Refuge is submitted for review. Questions concerning the supplement should be referred to Mr. D. R. Rippey, Chief, Arkansas River Section.

3. It is recommended that the supplement be approved as a basis for preparation of plans and specifications.

Charles L. Steel

1 Incl (15 cys)
as

CHARLES L. STEEL
Colonel, CE
District Engineer

ARKANSAS RIVER AND TRIBUTARIES
ARKANSAS AND OKLAHOMA

ARKANSAS RIVER
LOCK AND DAM NO. 9

SUPPLEMENT NO. 2
TO
DESIGN MEMORANDUM NO. 1, GENERAL

FISH AND WILDLIFE FACILITIES AT HOLLA BEND
NATIONAL WILDLIFE REFUGE

PREVIOUSLY ISSUED AND CURRENTLY SCHEDULED DESIGN MEMORANDUMS

Memo No.	Subject	Date submitted or scheduled	Date approved
1	General	5 Mar 65	9 Jun 65
	Supplement No. 1, Groundwater Effects	27 Dec 65	11 Jan 66
	Supplement No. 2, Fish and Wildlife Facilities at Holla Bend National Wildlife Refuge	27 Nov 68	
2	Access and Service Facilities	11 May 64	14 Jul 64
	Supplement No. 1, Resident Construction Office	26 Mar 65	11 May 65
	Revision to Suppl. 1 to Delete Bituminous Surfaces	15 Apr 65	14 May 65
	Real Estate		
Ltr DM	Access Roads	14 Oct 64	21 Dec 64
3-1	Dam Site, Work Area, Quarry Area, and Public Use Area	9 Apr 65	24 Jun 65
	Supplement No. 1, Borrow Area	8 Jul 65	28 Jul 65
	Supplement No. 2, Fee Title Limitation	3 Nov 65	9 Feb 66
	Supplement No. 3, Additional Costs of Land in Resiting Public Use Area	18 May 67	24 Jul 67
3-2	Navigation Pool	9 Mar 66	25 Apr 66
	Supplement No. 1, Additional Land for Clearing	12 Apr 67	19 May 67
	Relocations		
7-1	Dardanelle Highway Bridge - Arkansas State Highway 7	21 Jan 66	28 Apr 66
	Supplement No. 1 - Pier Protection	31 Aug 66	8 Sep 66
7-2B	Arkansas Louisiana Gas Company Pipeline	15 Sep 66	13 Oct 66
7-2C	Southwestern Bell Telephone Company - Telephone Line	3 Mar 65	16 Mar 65
7-2D	First Electric Cooperative Corporation - Power Lines	1 Mar 65	19 Mar 65

LOCK AND DAM NO. 9

PREVIOUSLY ISSUED AND CURRENTLY SCHEDULED DESIGN MEMORANDUMS (con.)

Memo No.	Subject	Date submitted or scheduled	Date approved
	Relocations (con.)		
7-2F	OMR Pipeline Company	21 Sep 66	13 Oct 66
	Supplement No. 1, New Plan for Relocation of OMR Pipeline	16 Oct 67	1 Nov 67
7-3	Drainage Structure - Conway County Drainage and Levee District No. 1	13 Dec 67	28 Dec 67
	Reference Design Memorandums		
3-3 (L&D 7)	Dredging - Pools 7, 8, and 9	10 Jan 67	4 May 67
4 (L&D 8)	Construction Materials (Locks and Dams Nos. 8 and 9)	30 Apr 65	1 Jul 65
5 (L&D 7)	Dredging - Pools 7, 8, and 9	19 Oct 66	10 Jan 67
10 (PIM)	Preliminary Master Plan (Suppl. 4) (Locks and Dams Nos. 8, 9, and 13)	20 Oct 64	3 May 65
10 (L&D 8)	Master Plan (Locks and Dams Nos. 8, 9, and 13)	5 Feb 68	17 May 68
11 (L&D 8)	Clearing (Locks and Dams Nos. 8, 9, and 13)	10 Mar 67	28 Jun 67
11 Part II (L&D 4)	Alteration to Drainage Structures - Pools 7, 8, and 9	12 Apr 68	16 Jul 68

ARKANSAS RIVER AND TRIBUTARIES
ARKANSAS AND OKLAHOMA

ARKANSAS RIVER
LOCK AND DAM NO. 9

SUPPLEMENT NO. 2
TO
DESIGN MEMORANDUM NO. 1, GENERAL

FISH AND WILDLIFE FACILITIES AT HOLLA BEND
NATIONAL WILDLIFE REFUGE

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ARKANSAS AND OKLAHOMA

ARKANSAS RIVER
LOCK AND DAM NO. 9

SUPPLEMENT NO. 2
TO
DESIGN MEMORANDUM NO. 1, GENERAL

FISH AND WILDLIFE FACILITIES AT HOLLA BEND NATIONAL WILDLIFE REFUGE

SECTION I

INTRODUCTION

1-01. Purpose and scope. - This supplement is prepared in compliance with instructions included in 2d indorsement ENGCW-EZ dated 9 June 1965 to the transmittal letter for Design Memorandum No. 1, General, Lock and Dam No. 9, Arkansas River and Tributaries. It includes an evaluation of the effects of the Arkansas River plan on the Holla Bend National Wildlife Refuge operated by the U. S. Fish and Wildlife Service; a recommended plan for mitigating wildlife losses attributable to the Arkansas River plan; alternative plans considered for mitigating the wildlife losses; and design criteria, economic evaluation, and a construction schedule for the proposed construction.

1-02. Location. - The Holla Bend National Wildlife Refuge is located in Pope County, Arkansas, on the right bank of the Arkansas River between miles 241 and 249, about 16 miles upstream from Lock and Dam No. 9 and about 9 miles downstream from the Dardanelle Lock and Dam. The location of the Wildlife Refuge is shown on Plate 1.

1-03. Previous reports. -

a. Design Memorandum No. 1, General, Lock and Dam No. 9, dated February 1965. - A letter from the Fish and Wildlife Service dated 18 September 1964, included in Exhibit B of the design memorandum, contains the original recommendation by the Fish and Wildlife Service that a closure structure be constructed at Holla Bend. The discussion of this recommendation contained in paragraph 5-06a of the design memorandum stated that the low water dam is not an integral part of the project and cannot be constructed as a part of Lock and Dam No. 9. Reasons for reconsidering the request for the closure structure are stated in paragraph d of the 2d Ind ENGCW-EZ dated 9 June 1965 which approved the design memorandum as a basis for further planning.

b. Design Memorandum No. 3-2, Real Estate-Navigation Pool, Lock and Dam No. 9. This design memorandum was submitted 9 March 1966 and approved by 1st indorsement SWDRP dated 25 April 1966. It shows that no

interest in real estate is required for the Arkansas River Project at the location of the Holla Bend National Wildlife Refuge.

1-04. Existing facilities. -

a. The Holla Bend National Wildlife Refuge is a unit in the network of national waterfowl management facilities.

b. The area was created by the construction of a cutoff on the Arkansas River at Holla Bend between river miles 241 and 249. The area is generally semi-circular bounded on three sides by the old cutoff river bend and on the fourth side by the Arkansas River cutoff channel. The old river lake thus formed was about eight miles long at the beginning. However, it has filled in at the upper end until it is now only about six miles long. Since the Dardanelle powerplant has been in operation, the surface area of the lake has fluctuated on a daily basis between about 350 and 700 acres during periods of low flow in accordance with the power generation schedule. The total land and water area in the refuge is about 4,083 acres including the original acquisition of 4,068 acres and 15 acres of accreted riparian land. In addition, the U. S. Fish and Wildlife Service is acquiring 3,700 acres of land in the bendway area to include the outside stream banks and a buffer zone. This area will also include all additional land required for the closure structure site, impounded water, and borrow areas.

c. Through the natural sedimentation process, the upstream end of the old river channel has filled in to about elevation 300 feet above mean sea level. In addition, the U. S. Fish and Wildlife Service has constructed an earth levee across this end of the old channel with a top elevation varying from 314 to 317 feet msl. This structure serves as an access road and closure structure to retard further filling of the old river lake by sediment.

d. The downstream end of the old channel has remained open down to about elevation 278 feet msl. As this is several feet below the ordinary stages of the river, the pool elevation in the old river lake varies with the river stages.

e. The refuge is managed as a resting and feeding area for waterfowl, chiefly geese and ducks. The old river lake provides a resting place and the contained island is managed for food production.

1-05. Effects of the navigation pool. -

a. Lock and Dam No. 9 will be operated to provide adequate depths for navigation upstream to Dardanelle Lock and Dam and reregulate the releases from the Dardanelle powerplant. It would also serve as an afterbay for the Petit Jean pumped-storage hydroelectric project if it is authorized and built.

b. During periods of normal flow, reregulation of power releases from Dardanelle will cause the pool elevations at Lock and Dam No. 9, mile 224.9, to fluctuate between 284 and 287 feet msl. Correspondingly, pool

elevations at the wildlife refuge, mile 241, will fluctuate between 284 and about 290 feet msl. The lower elevations will result during periods of low power demand which may last more than 2 days on weekends. The higher elevations will result when the powerplant is operated at overload capacity. Under these conditions, the river water-surface fluctuation at Holla Bend will be about 6 feet when Lock and Dam No. 9 is placed in operation.

c. Until Lock and Dam No. 9 becomes operative in the summer of 1969, the range of water-surface fluctuation at the wildlife refuge will be greater than 6 feet because the minimum elevation will not be limited by the impoundment of Pool 9. Records from a water level recording gage located about 2 miles upstream from the refuge showed an average daily fluctuation of 5.4 feet with a maximum of about 10 feet for the period June through November 1967.

d. The pool fluctuations create a wide fringe of mud flats around the lake which will not produce waterfowl food plants. In addition, increased river traffic and disturbance in the main navigation channel past Holla Bend will prevent a high rate of waterfowl use in the pool area unless it is protected by a closure structure.

* * * * *

SECTION II

COORDINATION WITH THE U. S. FISH AND WILDLIFE SERVICE

2-01. Losses from fluctuating pool levels. -

a. The U. S. Fish and Wildlife Service estimates a reduction by the Arkansas River Project in the average annual waterfowl use on the Refuge from 10,000,000 duck-days and 1,000,000 goose-days to 6,000,000 duck-days and 400,000 goose-days (Appendix A, sheets 3-6). Therefore, losses of 4,000,000 duck-days and 600,000 goose-days are attributable to the project. It is the opinion of the Service that the closure structure would prevent these losses.

b. Although the closure structure is primarily a mitigation measure for waterfowl, it would enhance sport fishery. The U. S. Fish and Wildlife Service estimates that the average annual sport fishery use of the refuge would be increased from 1,000 man-days to 3,000 man-days by the project and closure structure, resulting in an enhancement of 2,000 average annual man-days.

2-02. Design requirements. - The U. S. Fish and Wildlife Service requested that the closure structure be designed to stabilize the water level in the Holla Bend Refuge lake at about the highest elevation experienced with full power generation at Dardanelle when such power generation releases are equal to or less than the natural flow of the river, which is about 80 percent of the time. This is about elevation 290 feet msl.

2-03. Adequacy of proposed plan. - The proposed plan presented in Section III meets the design requirement described in paragraph 2-02. When the natural flows in the river exceed the releases required for full power generation the closure structure would be overtopped and the level of the lake would be about the same as the river stages. This condition will prevail about 20 percent of the time, generally during the spring months. During these flooding periods, the Dardanelle spillway would be passing flows and the total outflow including power generation discharges would equal the flow into the Dardanelle pool. River stage fluctuations at Holla Bend would, therefore, be no greater than for pre-power generation conditions.

2-04. Lands. - The U. S. Fish and Wildlife Service has agreed to provide all lands and rights-of-way necessary for access, borrow areas, and construction of the closure structure. Therefore, no interest in lands would be required from project funds. According to its letter dated 4 November 1966 sheet 6 of Appendix A, acquisition was then under way. Such acquisition will be completed in time to permit construction of the structure during the summer and fall of 1969.

* * * * *

SECTION III

DESCRIPTION OF PROPOSED PLAN

3-01. General. - The proposed plan consists of an embankment dam with an overflow weir. A plan and elevation of the structure are shown on Plate 2.

3-02. Permanent structure. - Design of the embankment and overflow sections of the permanent structure is discussed in Sections IV and V and details of the design and cross sections of the structure are shown on Plate 3.

3-03. Diversion plan. - The diversion plan is shown on Plate 2. The top of the riverward cofferdam structure will be built to elevation 298, which is about the water surface elevation for a once in 3-year river discharge for the period from July to November, inclusive. The lakeside cofferdam will be built to elevation 293, which is about 1 foot above the elevation that will result from a once in 3-year runoff volume from the 63-square-mile drainage area. A 36-inch CMP with a flapgate to be installed in the left abutment for diversion of storm runoff will be plugged when the cofferdams are removed.

* * * * *

SECTION IV

HYDROLOGIC AND HYDRAULIC ANALYSIS

4-01. Weir crest elevation. - The maximum power release from Dardanelle Dam is 52,000 cfs with four turbines running at 15 percent overload. This corresponds to elevation 290 feet msl at the weir site, as shown on Plate 4. To eliminate power wave fluctuations in the waterfowl management area up to this elevation, it is proposed that the weir crest be set at elevation 290.

4-02. Hydraulic design conditions. - The type weir studied was limited to impervious embankments with stone protection because of the foundation conditions. The three conditions for design of the weir are: (1) interior runoff with low Arkansas River, (2) rapid rise on the Arkansas River, and (3) rapid fall on the Arkansas River. Studies of the three conditions indicated condition (2), the rapid rise on the Arkansas River, to be the most critical; thus, it controlled the weir design.

4-03. Arkansas river rating curve. - The Arkansas River rating curve for present conditions at mile 241, shown on Plate 4, was derived from experienced water-surface profiles for a range of discharges. This curve is applicable at the weir site as channel losses between the weir and river are insignificant.

4-04. Area-capacity. - The area and capacity curves for the waterfowl management pool are shown on Plate 5. These curves were developed from contour maps surveyed in 1966.

4-05. Arkansas river rapid rise. - The Arkansas River rapid rise used in the weir design was the experienced May 1957 flood at the Dardanelle gage. This is the maximum rate of rise in the period of record 1942 through 1965. A stage hydrograph of a section of the rapid rise developed for the weir site is shown on Plate 6.

4-06. Weir discharge rating. - The weir was rated using the submerged and free flow head-discharge relationships for nonaccess type embankments in WES Technical Report No. 2-650, "Stability of Riprap and Discharge Characteristics, Overflow Embankments," Arkansas River, Arkansas, dated June 1964. The discharge capacity of the weir was only needed for a limited number of headwater-tailwater relations; therefore, no general rating curve was derived. Equations used for discharge computations are shown under the inflow columns in Table No. 1.

4-07. Weir length. -

a. The Arkansas River rapid rise was routed into the waterfowl management pool using various assumed weir lengths. Stage hydrographs plotted from the routings for weir lengths of 500, 600, 800, and 1,250 feet are shown on Plate 6. Using the relations between head, tailwater, weir

TABLE NO. 1

ROUTING OF ARKANSAS RIVER RAPID RISE

Time (hours)	Rapid rise river elevation (ft msl)	Trial waterfowl pool elevation (ft msl)	H Head on weir (feet)	h Pool elevation above weir crest (feet)	C_s Submerged discharge coefficient	Inflow (cfs) Free flow $Q=1650\ H^{1.62}$	Inflow (cfs) Submerged flow $Q=C_s\ Lh\sqrt{2g(H-h)}$	Average inflow (acre-feet)	Storage (acre-feet)	Computed waterfowl pool elevation (ft msl)
0	290.0	290.0	0	0		0			4,850	290.0
								104		
1	291.3	290.1	1.3	0.1	-	2,520	-		4,950	290.1
								425		
2	292.6	290.7	2.6	0.7	-	7,760	-		5,380	290.7
								942		
3	293.9	291.8	3.9	1.8	-	15,000	-		6,320	291.8
								1,610		
4	295.2	293.4	5.2	3.4	-	23,900	-		7,930	293.4
								2,290		
5	296.4	295.5	6.4	5.5	1.25	-	31,400		10,220	295.5
								2,380		
6	297.5	297.3	7.5	7.3	1.65	-	26,000		12,600	297.3
								1,680		
7	298.4	298.37	8.4	8.37	2.0	-	14,800		14,280	298.37

crest, and discharge taken from the routings and the stone stability curves (Plate 48) of the above reference, the minimum weir length at which stone graduation A (Riprap 5) would be stable was 600 feet. Routing computations of the rapid rise for the 600-foot selected weir length is shown on Table No. 1.

b. Elevation 288.6 feet msl is the minimum starting waterfowl pool elevation at which Riprap 5 is stable through the rapid rise. The probability of the rapid rise coincident with a 288.6 waterfowl management pool elevation is remote as the river exceeds the weir crest about 20 percent of the time and about 2 months of evaporation and leakage with no inflow would be required to lower the pool to elevation 288.6.

4-08. Abutment embankment elevations. - The abutment embankments were set at elevation 298 feet msl. As shown on Plate 6 for the 600-foot weir, this is the elevation at which there is no head differential between the river and the waterfowl management pool during the Arkansas River rapid rise.

4-09. Abutment embankment protection from wave action. - In lieu of the usual riprap protection from wave action, it is proposed to protect the embankments on both the river and waterfowl pool sides with turfed berms. The berms would extend a minimum of 60 feet from each side of the embankments. They would have a 1 on 15 slope from elevation 293 feet msl at the embankments to elevation 289 feet msl. The slope below elevation 289 feet msl would be 1 on 3. The berms would be constructed from material in the cofferdams after the weir has been completed.

4-10. Cofferdam elevations and diversion during construction. -

a. The weir is scheduled to be constructed during the months of July through November, inclusive. Therefore, cofferdam elevations and the diversion capacity were based on frequency studies for thie 5-month period.

b. The top of the riverside cofferdam is set at elevation 298 feet msl, which corresponds to the Arkansas River regulating discharge of 150,000 cfs plus 0.5-foot of freeboard. The 150,000 cfs flow can be expected about once every 3 years during the 5-month construction period.

c. The cofferdam elevation on the waterfowl pool side is based on routing a 3-year runoff volume on the 63 square-mile tributary area through a 36-inch CMP diversion pipe, invert elevation 283 feet msl. The 3-year runoff volume of 1.44 inches was derived from frequency analysis of 20 years of experienced tributary runoff between gaging stations on the Arkansas River during the 5-month construction period. The runoff from 53 square miles within the leveed area tributary to the bendway was routed through the drainage structures in the levees and the outflow combined with the runoff from the unleveed area to form the inflow to the waterfowl pool. The maximum ponding elevation of the 3-year runoff volume was 291.9 feet msl. The top of the cofferdam on the waterfowl pool side was set at elevation 293, which allows for 1.1 feet of freeboard.

4-11. Effects of weir on drainage and flooding. - The lowest culverts that drain into the waterfowl management pool are four 8- by 8-foot RCB's, invert elevation 292 feet msl, and a 36-inch CMP, invert elevation 297 feet msl. The 600-foot weir has sufficient capacity to discharge all expected interior runoff with ponding limited to elevation 292-294 feet msl. Ponding to these elevations would not affect drainage through the culverts that drain into the waterfowl pool.

* * * * *

SECTION V

FOUNDATIONS AND MATERIALS

5-01. Investigations, explorations, and tests. -

a. General. - The plan of borings is shown on Plate 7. Logs of borings are shown on Plates 8 and 9.

b. Structure foundation, soils. - Eight borings were made along the centerline of the proposed structure with a Failing 1500 truck-mounted drill rig. These borings, except for boring HB-4, were approximately 30 feet deep. Boring HB-4 was 40 feet deep and extended to shale at elevation 249 feet above mean sea level. Impervious materials were sampled with a 4-inch-diameter power auger. Penetration tests with a split-spoon sampler were performed in the sands in all holes except HB-2 and 3, and the penetration resistance in blows per foot was recorded. The elevation of the water table was obtained approximately 18 hours after the completion of each boring. Laboratory tests included water content for soils above the water table, mechanical analyses on pervious materials, and Atterberg limits on typical clays.

c. Borrow materials. - Forty-three borings in potential borrow areas were made with a 4-inch Iwan auger. The borings generally extended to or slightly below the water table elevation. The water table elevation was recorded after the completion of each hole. Laboratory tests included water content for soils above the water table and mechanical analyses of pervious materials.

5-02. Results of investigations, explorations, and tests. -

a. Structure foundations. - The foundation clays are soft, wet, recent alluvial deposits. The estimated shear strength of these saturated partly consolidated clays ranges from 0.2 to 0.4 ton per square foot. The natural water content of the clay ranged from 19 to 67 percent with an average of 37 percent. The average water table was at elevation 282. The average liquid limit of the clays (CH) was 61 and the average plastic limit was 18. The pervious materials which underlie the clays are generally below the water table, and consist of silty sand (SM) and poorly graded sand (SP) with varying amounts of gravel. Standard penetration resistance of the pervious material ranged from 10 to 59 blows per foot. Generally, the blows increased with depth. The D_{10} of the pervious materials ranged from 0.08 to 0.33 millimeter. The pervious materials were encountered between elevation 279 and 249 feet msl.

b. Borrow materials. - Generally, the impervious materials encountered in the recent alluvial deposits consist of soft clays (CL) and (CH). Some firmer drier clays occurred in the top 3 feet of the borings. The water content of the clays ranged from 28 to 48 percent with an average of 36 percent. The average water table was at elevation 282 feet msl.

Drying of the clay materials in the borrow pit or on the fill would be necessary in order to obtain satisfactory compaction. Adequate impervious material is available for the core of the permanent embankment and also for the core of the cofferdams. The wet impervious clays would have to be placed in thin layers and dried to remove 10 to 15 percentage points of water in order to obtain proper compaction. Impervious clays stockpiled under the dredging contract would also require drying to obtain a compactible water content. Random fill materials consisting of sandy silts (ML) and silty sands (SM) were encountered in the alluvial deposits above elevation 300 feet msl. The mixture of random materials would be semipervious and may require additional moisture for proper compaction.

5-03. Materials for embankment construction. -

a. Soils borrow. - The borrow areas are located on the west side of the old bendway channel on land which is part of the Holla Bend refuge. The proposed stockpile of impervious borrow materials would be located on the bank of the active channel north of the alinement.

b. Gravel for bedding. - Gravel for bedding is available from the Mobley Sand and Gravel Co. plant at Dardanelle on the east side of the river. Processed crushed stone would be required to meet the gradation specifications for bedding material.

c. Rock for outlet weir and embankment protection. - The quarries from which graded stone of the size for Riprap No. 5 can be produced are limited in number. Large stone can be produced from the quarry on the west side of the river adjacent to the Dardanelle access road.

5-04. Structure design. -

a. General. - The proposed facility would consist of a sheet pile cutoff incased in earth and riprap. Adjacent nonoverflow earth dikes would be provided with wide berms for resistance to wave erosion. The sheet pile cutoff would be necessary to reduce the seepage through the riprap to a rate which would allow the waterfowl pool to remain at approximate elevation 290 feet msl. The sheet pile cutoff would also protect the underlying clay embankment from degradation by seepage and reduce underseepage through the existing pervious foundation material. Plans and typical sections for the structures are shown on Plates 2 and 3.

b. Overflow weir. - The sheet pile cutoff section of the weir would have a uniform top elevation of 290.0 feet msl. The pile would be driven to a bottom elevation of 279.0 feet msl except in the old bendway channel area where it would be driven to elevation 275.0 feet msl. It would be corrosion protected by a coal tar epoxy paint applied on both sides from the top down to 5 feet below the top of the impervious core in which it would be embedded. It would be necessary to excavate to elevation 277± feet msl in the old active bendway channel in order to remove the soft

mucky material. Backfill in the channel above elevation 277± feet msl would be a minimum of 8 feet in width and would consist of compacted clay. The compacted clay would envelop the sheet pile wall to elevation 286 feet msl. Riprap 5 with a suitable transition would be used to embed the balance of the sheet pile wall to its crest, which is elevation 290 feet msl. The crest width of the overflow weir would be 12 feet.

c. Embankment. - The embankment would consist of an impervious clay core to elevation 295 feet msl with 1 on 2 side slopes. The outer shells would have 1 on 3 slopes and would consist of random fill materials which are suitable for the initial embankment construction. The spoil materials from the cofferdam would be used to construct a berm 60 feet wide starting at elevation 293.0 feet msl on both sides of the embankment. The section of the embankment above elevation 290 feet msl would be protected from erosion by seeding, mulching, and fertilizing, and possibly some localized sodding. The impervious surface of the embankment foundation for a distance of 250 feet upstream and downstream of the embankment toe would be left intact to act as an underseepage barrier.

d. Stability. - In the overflow weir section the controlling criterion for stability is adequate resistance of the materials to hydraulic attack from overflow and/or wave action. In the embankments at each end of the overflow weir the proposed sections would be even more stable than the existing flood protection (project levees) in the general area which has similar materials and compaction, and have greater maximum heights and head differentials. Therefore, particular stability analyses as to shear failure in these embankments are considered to be unnecessary.

5-05. Cofferdams and dewatering. -

a. Cofferdams. - The core of the cofferdams would be constructed of impervious material on the undisturbed surface clay. Random materials would be used for the outer shells. The upstream cofferdam would be constructed with a crown width adequate to serve as a haul and access road. A 36-inch CMP with a flapgate would provide temporary outlet for the runoff from the old bendway drainage area. The location of the cofferdams and 36-inch CMP are shown on Plate 2.

b. Dewatering. - The amount of water to be pumped from the sump inside the cofferdam would depend on the heads outside and the permeability of the cofferdam materials. It is estimated that dewatering below elevation 277 feet msl in the area of the old river channel could be accomplished by a single stage system of well points. It is further estimated that elsewhere dewatering could be satisfactorily accomplished by a system of collecting sumps and the sump pumps used for removing surface runoff.

* * * * *

SECTION VI

ECONOMIC ANALYSIS

6-01. Estimated first cost. - The estimated first cost of the closure structure is $207,000. Land costs are excluded because the U. S. Fish and Wildlife Service is purchasing additional land for the Holla Bend Refuge and has agreed to provide that necessary for construction and operation of the project. The detailed estimate based on July 1968 price levels is presented in Table No. 2.

TABLE NO. 2

DETAILED COST ESTIMATE

Acct. No.	Item	Unit	Quantity	Unit cost	Estimated cost
06.	Sheet piling - MA 22 (M-115) Epoxy paint	S.F.	7,960	$5.16	$41,100
	Stripping	C.Y.	6,500	0.30	1,950
	Excavation, channel muck	do	1,200	0.70	840
	Impervious fill	do	9,000	1.00	9,000
	Impervious fill - random	do	22,500	0.85	19,135
	Bedding material	do	600	6.00	3,600
	Riprap No. 5	do	4,000	8.50	34,000
	Riprap No. 2	do	3,100	6.25	19,375
	Turfing (seeding or sodding)	Acre	2.7	400.00	1,080
	Cofferdams - Random impervious fill	C.Y.	31,000	0.40	12,400
	Dewatering	L.S.	Job		16,000
	Degrade cofferdam to El. 290 and place material on slopes	C.Y.	6,900	0.20	1,380
	Excavation - ditch and trench for pipe	do	4,500	0.25	1,135
	Corrugated metal pipe - 36-inch	L.F.	100	14.00	1,400
	Flapgate - 36-inch	Each	1	450.00	450
	Subtotal				162,845
	Contingencies, 12%				20,155
	Estimated payment to contractor				183,000
30.	Engineering and design				12,000
	Supervision and administration				12,000
	Total estimated Federal First cost				207,000

6-02. Estimated annual charges. - The estimated average annual charges include interest and amortization on the estimated investment, for an interest rate of 2-1/2 percent and an amortization period of 100 years, and the average annual cost of operation and maintenance. The estimated investment is the same as the first cost because the estimated construction period is less than 2 years and, therefore, there would be no interest during construction. The average annual cost of operation and maintenance was estimated by the U. S. Fish and Wildlife Service to be $5,000. There are no major items in the project with a useful life less than that of the overall development, therefore, major replacement costs are not applicable. A summary of cost and annual charges is presented in Table No. 3.

TABLE NO. 3

SUMMARY OF COSTS AND ANNUAL CHARGES

First cost	$207,000
Interest during construction (Construction period less than 2 years)	0
Investment	207,000
Annual charges:	
Interest and amortization (2-1/2 percent, 100 years)	5,700
Operation and maintenance	5,000
Total	10,700

6-03. Benefits. -

a. The U. S. Fish and Wildlife Service estimates that the closure structure would prevent the loss of 4,000,000 duck-days and 600,000 goose-days on an average annual basis. This estimate was furnished by letter dated 4 November 1966 and is presented on sheet 4 of Appendix A. A unit value of $0.0045 per duck-day and $0.0089 per goose-day was used in estimating the average annual benefits. These are the same values used in an economic analysis for development of a national wildlife refuge on the Walter F. George Reservoir in the Mobile District (Senate Document No. 109, 87th Congress, 2d session). Average annual losses prevented by the closure structure (benefits) on this basis are as follows:

4,000,000 duck-days @ $0.0045 =	$18,000
600,000 goose-days @ $0.0089 =	5,300
Total benefits	23,300

b. The U. S. Fish and Wildlife Service also estimates that the closure structure would enhance sport fishing in the old river lake by 2,000 man-days on an average annual basis. This estimate is also shown on sheet 4 of Appendix A. Based on a unit value of $1. per man-day, which is within the values suggested in Supplement No. 1 to Senate Document No. 97, 87th Congress, 2d session, the enhancement benefit is $2,000. This incidental benefit is not considered applicable for economic evaluation of the closure structure because the structure is for mitigating losses and thus should be justified solely on the basis of losses prevented.

6-04. Economic justification. - The total average annual charges from paragraph 6-02 are $10,700 and the total average annual benefits from paragraph 6-03 applicable for justification of the mitigation structure are $23,300. Thus, the benefit-to-cost ratio for the mitigation structure is 2.2 to 1. This shows that the structure is well justified economically from a benefit-to-cost standpoint. The U. S. Fish and Wildlife Service estimated the first cost of an alternative structure to accomplish the same purpose as the closure structure to be $500,000, as shown on sheet 5 of Appendix A. It further estimated the average annual operation and maintenance cost for such a structure to be $16,000. Therefore, the proposed closure structure would be the most economical way of mitigating the fish and wildlife losses.

6-05. Other plans considered. -

a. Several plans similar to the one proposed but with different weir lengths were considered. However, the weir section is more expensive than embankment sections; therefore, plans with longer weirs are more costly than the proposed plan. Plans with weir lengths of less than 600 feet, which is the length of the weir for the proposed plan, were found to be unstable under critical hydraulic design conditions.

b. A plan similar to the proposed plan except with a concrete instead of sheet pile cutoff wall was considered. It would be slightly more expensive than the proposed plan to construct and maintain. It would also be more rigid and thus subject to failures that would require expensive repairs. Further, the sheet pile cutoff of the proposed plan would extend further into the foundation material than the concrete cutoff wall and thus be more effective against underseepage.

c. The proposed plan was selected over others considered because it is better from an engineering standpoint and more economical.

* * * * *

SECTION VII

SCHEDULES

7-01. General. - It is proposed to construct the closure structure in 1969 as soon as possible after the usual spring high-water season. The information presented in the subsequent paragraphs of this section were developed to meet this objective and will be utilized to add this work to future PB-3 estimates and PB-2a schedules.

7-02. Design and construction. - The proposed design and construction schedule is shown below.

Submit plans and specifications	Mar 69
Advertise	Apr 69
Award contract	Jun 69
Complete construction	Nov 69

7-03. Fund requirements. - The estimated fund requirements are presented below.

Cost to 30 Sep 68		$5,300
FY 69	2d Quarter	3,200
	3d Quarter	3,200
	4th Quarter	1,500
FY 70	1st Quarter	100,000
	2d Quarter	93,800
	Total	207,000

* * * * *

SECTION VIII

CONCLUSIONS AND RECOMMENDATIONS

8-01. Conclusions. -

a. The U. S. Fish and Wildlife Service has requested a closure structure at the Holla Bend National Wildlife Refuge to mitigate damages to fish and wildlife caused by operation of the Arkansas River Project. The estimated average annual damages are $23,300.

b. Investigations reveal that the estimate of damages is reasonable and that a closure structure is economically justified and the most economical means of mitigation.

c. The damages result from water-surface fluctuations in the old river lake at the refuge caused by flows released through the upstream Dardanelle project powerplant during periods of normal and low flow conditions in the Arkansas River. These river flow conditions prevail about 80 percent of the time. Flows released through the powerplant vary from 0 to about 52,000 cfs according to the power generation schedule. Consequently, the water-surface elevation in the old river lake at the refuge will fluctuate about 6 feet with Pool 9 in operation. Until Lock and Dam No. 9 is in operation, the fluctuations will be even greater.

d. The closure structure was designed in close coordination with the U. S. Fish and Wildlife Service. Therefore, no difficulty is anticipated in obtaining approval of that agency for construction of the structure.

8-02. Recommendations. - It is recommended that this supplement be approved as a basis for design and construction of the closure structure at the Holla Bend National Wildlife Refuge as a part of Lock and Dam No. 9 at an estimated cost of $207,000.

* * * * *

SWLGW-5 11 August 1965

Regional Director
Region 4
U. S. Fish and Wildlife Service
Peachtree-Seventh Building
Atlanta, Georgia 30323

Dear Sir:

Reference is made to your letter CE-SM-a dated 18 September 1964, which outlined recommendations regarding the fish and wildlife aspects of pool No. 9 of the Arkansas River Multiple-Purpose Plan.

Review of the General Design Memorandum has been completed and it has been found necessary to obtain additional information to evaluate the recommendation that a closure structure be constructed across the downstream outlet of the old channel at Holla Bend. The data desired from the Fish and Wildlife Service for this evaluation are as follows:

a. The estimated damages that will occur without the closure structure.

b. The estimated damages that will be prevented by construction of the closure structure and also any benefits that it would provide.

We are aware of your position that measures to mitigate fish and wildlife losses need not be justified in the strict sense of an economic benefit-cost ratio. However, if you can provide sufficient data on the estimated damages to compare with the cost of the structure it will be appreciated.

Sincerely yours,

FRANK P. BANE
Colonel, CE
District Engineer

APPENDIX A
Sheet 1 of 6

SWLGW-5

29 April 1966

Regional Director
Bureau of Sport Fisheries and Wildlife
U. S. Fish and Wildlife Service
Peachtree-Seventh Building
Atlanta, Georgia 30323

Dear Sir:

This is in reply to your letter dated 19 April 1966 regarding the effects of the Arkansas River Multiple-Purpose Plan on the Holla Bend National Wildlife Refuge.

The design and cost studies which you requested will soon be initiated. As the studies progress, we will request any additional information needed from your staff as found necessary.

My letter to you dated 11 August 1965 outlined the need for data on estimated damages without the structure and benefits from its construction. This information is still desired from your agency for use in evaluating the results of design and cost studies.

Sincerely yours,

FRANK P. BANE
Colonel, CE
District Engineer

UNITED STATES
DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
BUREAU OF SPORT FISHERIES AND WILDLIFE
PEACHTREE-SEVENTH BUILDING
ATLANTA, GEORGIA 30323

November 4, 1966

District Engineer
U. S. Army, Corps of Engineers
P. O. Box 867
Little Rock, Arkansas 72203

Dear Sir:

Reference is made to our letter of June 1, 1966, and prior correspondence regarding the effects of the Arkansas River Multiple-Purpose Project on the Holla Bend National Wildlife Refuge, our proposal for a closure structure in the lower end of the Holla Bend Cutoff Channel, and your need for our estimate of damages prevented and any benefits provided by the installation of this structure.

A closure structure, designed to stabilize bendway water levels at about the highest elevation experienced at Holla Bend with full power generation at Dardanelle Dam during normal and low flow river conditions, was recommended in our report of September 18, 1964, prepared in accordance with the Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 U.S.C. 661 et seq.). Stabilization of water levels in the bendway is considered necessary to prevent damages to waterfowl habitat at Holla Bend Refuge resulting from the Arkansas River project. We believe that the installation of a closure weir would mitigate project-occasioned damages, and additionally would enhance the sport fishing potential of the refuge.

Our observation of river conditions at Holla Bend during the past year, and analysis of project data provided us during meetings and correspondence with your planning staff, indicate that water levels in Holla Bend have fluctuated in accordance with power generation schedules and water releases at Dardanelle Dam. During extended low flow periods, daily differences in water levels at Holla Bend have varied as much as 7 feet under full power-generating conditions. Water surface area in the bendway has varied from about 270 acres to about 650 acres in extent, and a wide fringe of mud flats that are daily flooded and exposed has failed to grow waterfowl food plants and has otherwise resulted in an undesirable condition.

We recognize that this daily fluctuation of water levels will be lessened from 7.0 feet to about 5.4 feet after completion and impoundment of Lock and Dam No. 9. This degree of fluctuation will continue to cause almost as much damage to fish and wildlife, however. After completion of navigation features, increased river traffic and disturbance in the main navigation channel past Holla Bend will prevent high waterfowl use in this unprotected pool area. The protected cutoff bendway area will then assume even greater importance in the maintenance of waterfowl populations at Holla Bend Refuge.

The cutoff bendway, stabilized by means of the proposed closure structure, would in addition to restoring a favorable waterfowl-management capability, provide improved conditions for sport fishing and other water-based recreation.

The legislative history of the Fish and Wildlife Coordination Act indicates that measures adopted to mitigate losses to fish and wildlife resources need not be justified on a monetary basis. The general policy of the Bureau is in accord with this principle. In this instance, we have made an evaluation of the waterfowl-day loss at Holla Bend Refuge attributable to the Arkansas River project, and have estimated waterfowl use expected with the structure in place. We have also estimated an expected increase in sport fishing.

Average annual waterfowl use on the Refuge without effects induced by the navigation project is estimated to be 10,000,000 duck-days and 1,000,000 goose-days. This usage will be reduced to 6,000,000 duck-days and 400,000 goose-days by the project if the requested closure structure is not built. Thus, construction of the closure will prevent a loss of 4,000,000 duck-days and 600,000 goose-days use annually.

Although the closure structure is primarily a mitigation measure for waterfowl, it will provide an incidental sport fisheries enhancement. This enhancement will amount to 2,000 man-days annually, since use with the structure is expected to be 3,000 man-days while without the structure (or without the project) it is 1,000 man-days annually.

For purposes of comparison, we have calculated the least alternative cost of providing a unit of comparable habitat with an average annual capacity of 4,000,000 duck-days and 600,000 goose days. This comparison is shown in Table 1.

Table 1

Arkansas River Navigation Project
Holla Bend National Wildlife Refuge, Arkansas

Schedule of Comparative Costs
Impoundment Structure and Least Costly Alternative Development

Initial Cost	Alternative Development[1]	Impoundment Structure[2]
Levees, structures, etc.	$450,000	$400,000
Water supply pumps and facilities	30,000	-
Supplementary developments	20,000	20,000
TOTAL	$500,000	$420,000
Annual Cost		
Operation	$ 6,000	-
Maintenance	10,000	$ 5,000
TOTAL	$ 16,000	$ 5,000

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1. Leveed area on refuge and water-supply facilities capable of providing 4,000,000 duck-days use and 600,000 goose-days use.

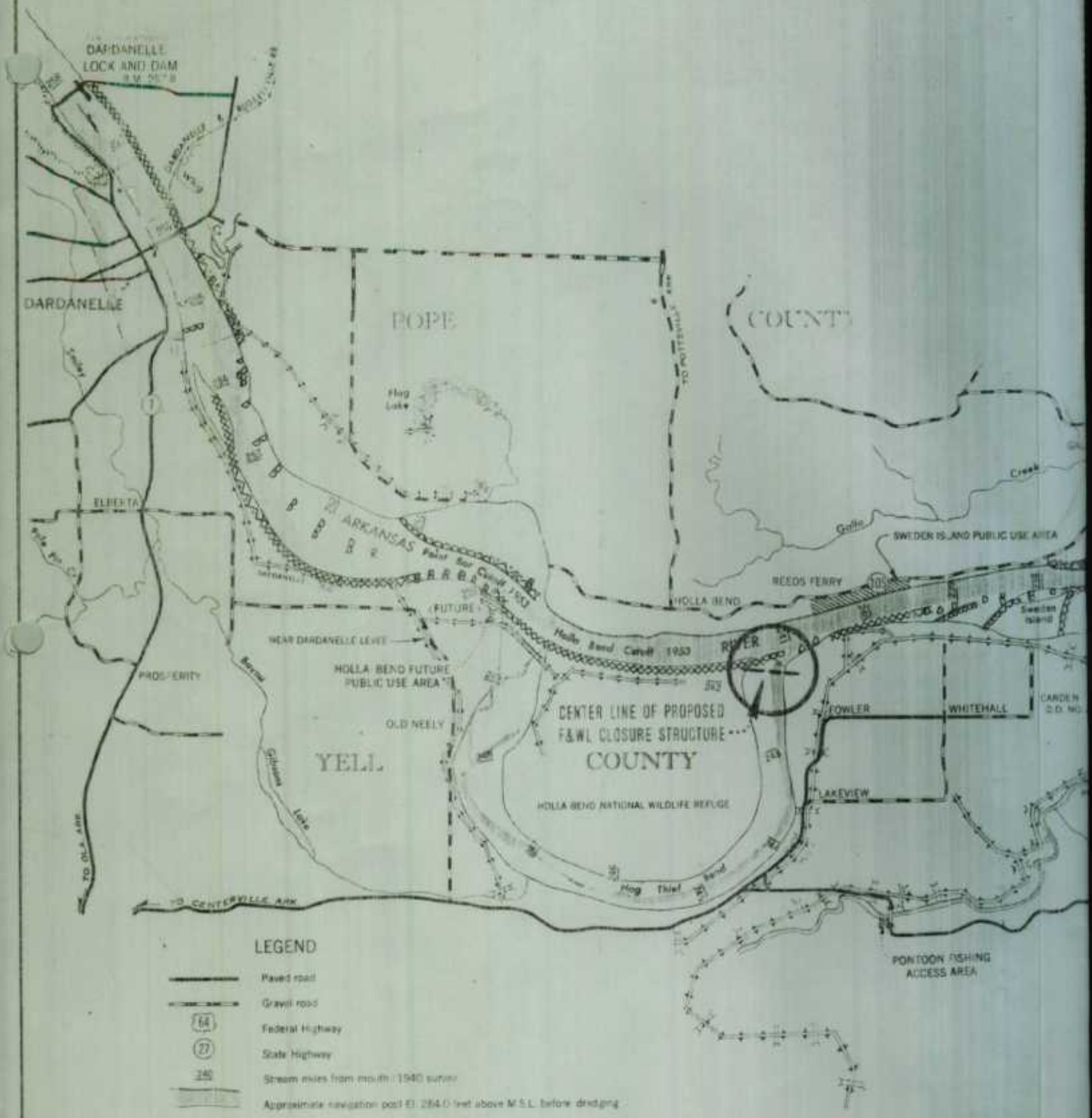
2. Interim cost estimate pending completion of Corps' design and cost studies.

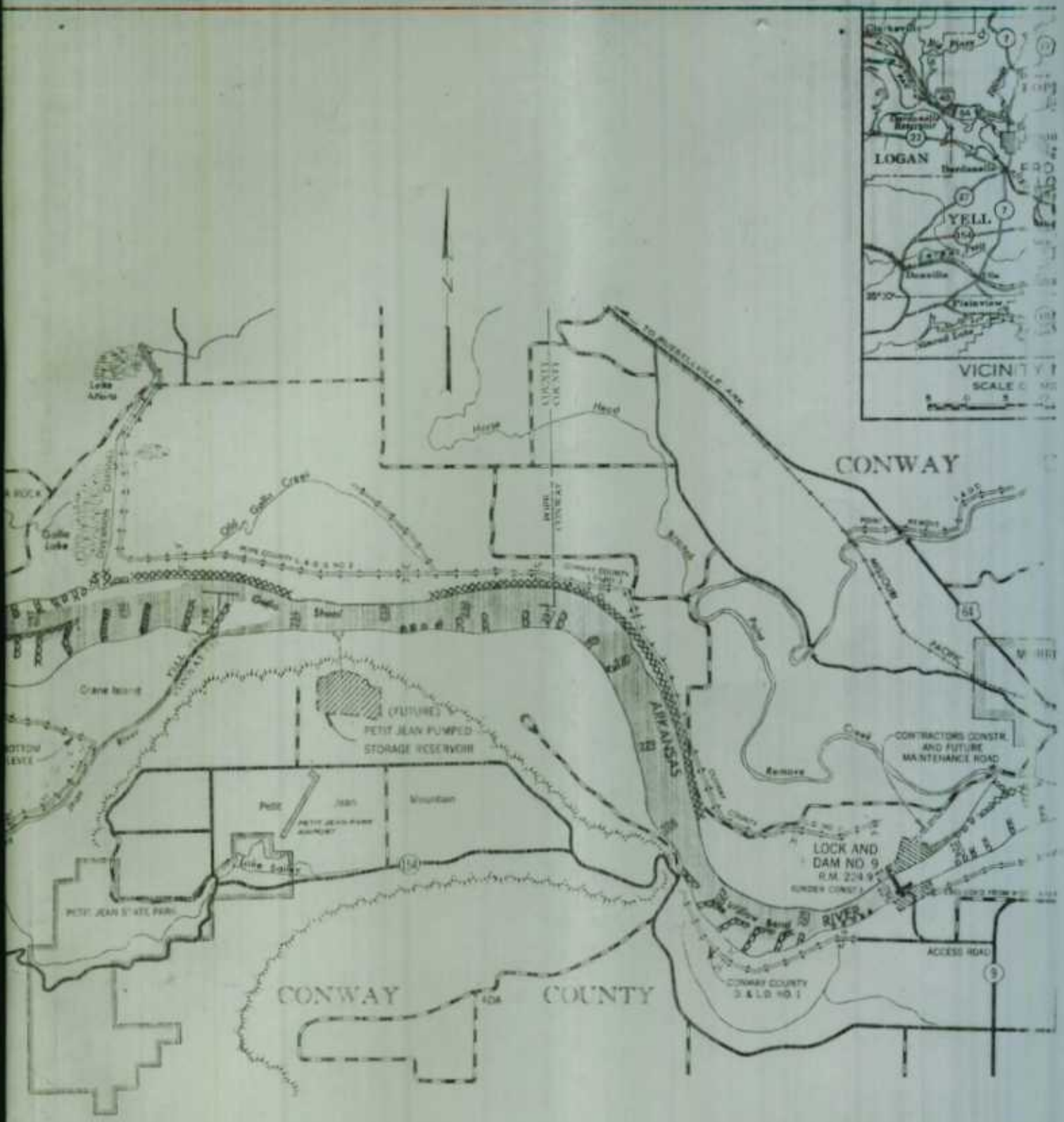
With the expectation that the closure will be constructed, this Bureau has initiated acquisition of about 3,700 acres of lands in the bendway area to include all of the outside stream banks and a surrounding buffer zone. This land acquisition will include all bendway lands required for the closure structure site and impounded waters. At the upstream end of the bendway, the Bureau has already constructed a closure fill and access road at a cost of $138,000, which we believe will be effective in arresting sedimentation and prolonging the life of the bendway water area for many years.

We trust that the information provided will serve your needs in completing your design and cost studies for a closure structure. Your interest and continued effort to achieve effective development of fish and wildlife resources on the Holla Bend National Wildlife Refuge in connection with the Arkansas River project is greatly appreciated.

Sincerely yours,

Walter A. Gresh
Regional Director


DARDANELLE LOCK AND DAM
DARDANELLE
POPE
COUNTY
Flag Lake
ARKANSAS
ELDERTA
REEDS FERRY
HOLLA BEND
(FUTURE)
Holla Bend Cutoff 1953
RIVER
NEAR DARDANELLE LEVEE
HOLLA BEND FUTURE PUBLIC USE AREA
PROSPERITY
OLD NEELY
CENTER LINE OF PROPOSED F&WL CLOSURE STRUCTURE
YELL
COUNTY
HOLLA BEND NATIONAL WILDLIFE REFUGE
Gilmore Lake
Hog Thief Bend
FOWLER
WHITEHALL
LAKEVIEW
SWEDEN ISLAND PUBLIC USE AREA
PONTOON FISHING ACCESS AREA
TO CENTERVILLE ARK
TO OLA ARK
LEGEND
Paved road
Gravel road
Federal Highway
State Highway
Stream miles from mouth (1940 survey)
Approximate navigation pool El. 284.0 feet above M.S.L. before dredging
Drainage structures near or below regulation pool elev. 289.0
Lock and dam
Proposed recreation area
Utility crossing
Dardanelle municipal water supply wells
Ark. valley industries poultry proc. plant water supply wells



ARKANSAS RIVER AND TRIBUTARIES

LOCK AND DAM
PROJECT LOCATION
FISH AND WILDLIFE
HOLLA BEND RE
SCALE: AS SHOWN
LITTLE ROCK DISTRICT, CORPS
LITTLE ROCK, ARKANSAS,
DESIGNED: WAT TO ACCOMPANY SUPPL
DRAWN: DLL TO GENERAL D. M. NO.


49
HOLLA BE
DAIL
4-8
30°

ARKANSAS RIVER AND TRIBUTARIES ARKANSAS RIVER, ARKANSAS

LOCK AND DAM NO. 9

AERIAL MOSAIC

FISH AND WILDLIFE FACILITIES

HOLLA BEND REFUGE

SCALE 1" = 2000'

LITTLE ROCK DISTRICT, CORPS OF ENGINEERS

LITTLE ROCK, ARKANSAS, MARCH 1967

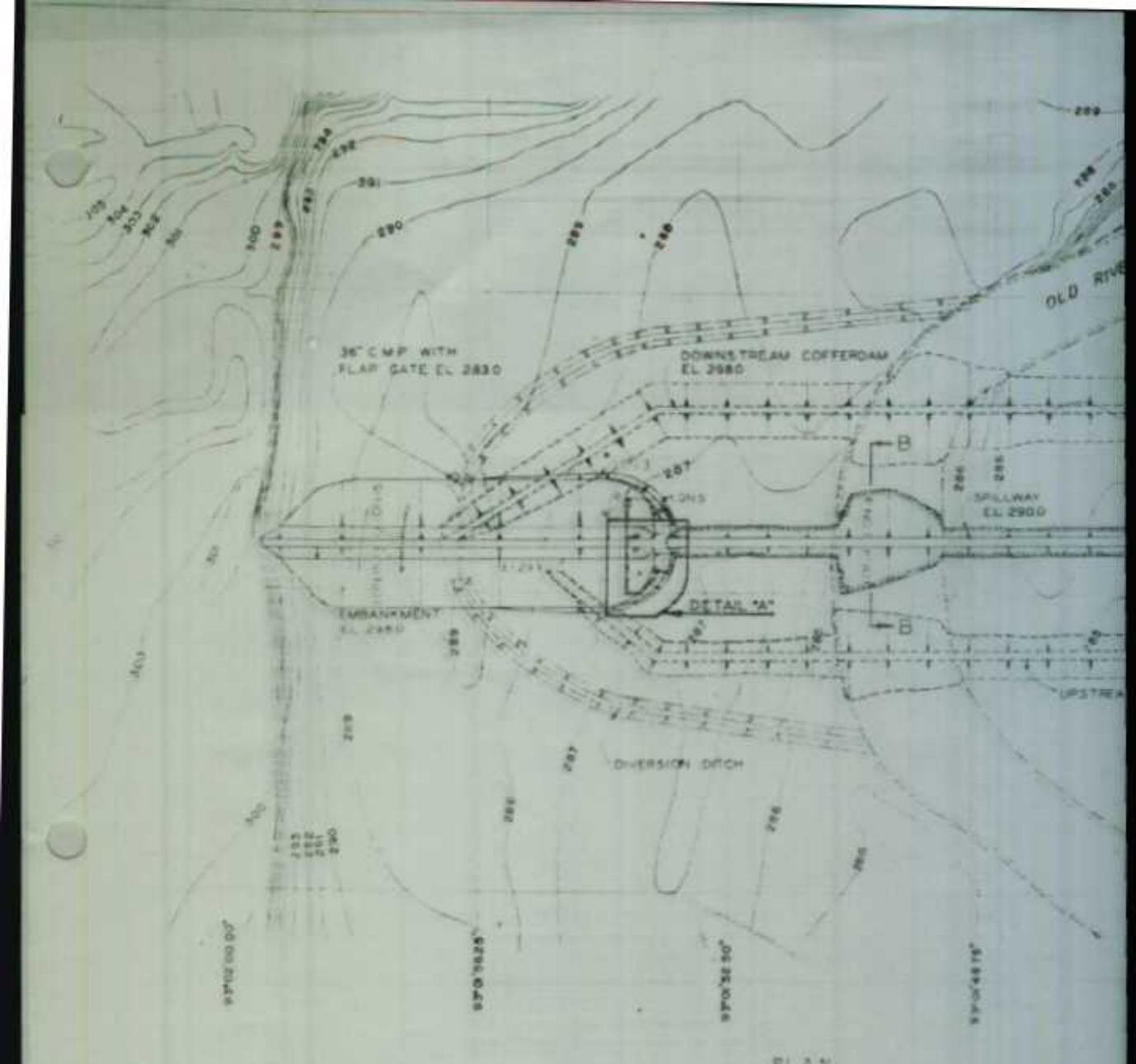
DESIGNED NRH TO ACCOMPANY SUPPLEMENT NO. 2 SERIAL 8515

DRAWN RLZ TO GENERAL D. M. NO. 1

CHECKED ACA DATED NOVEMBER 1966

63, 181A

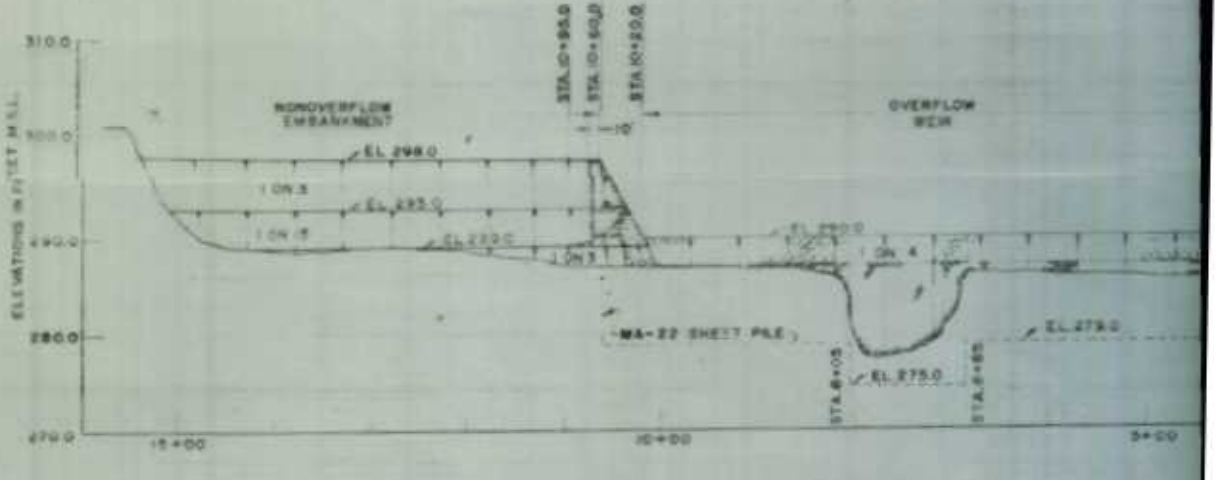
PLATE 1A



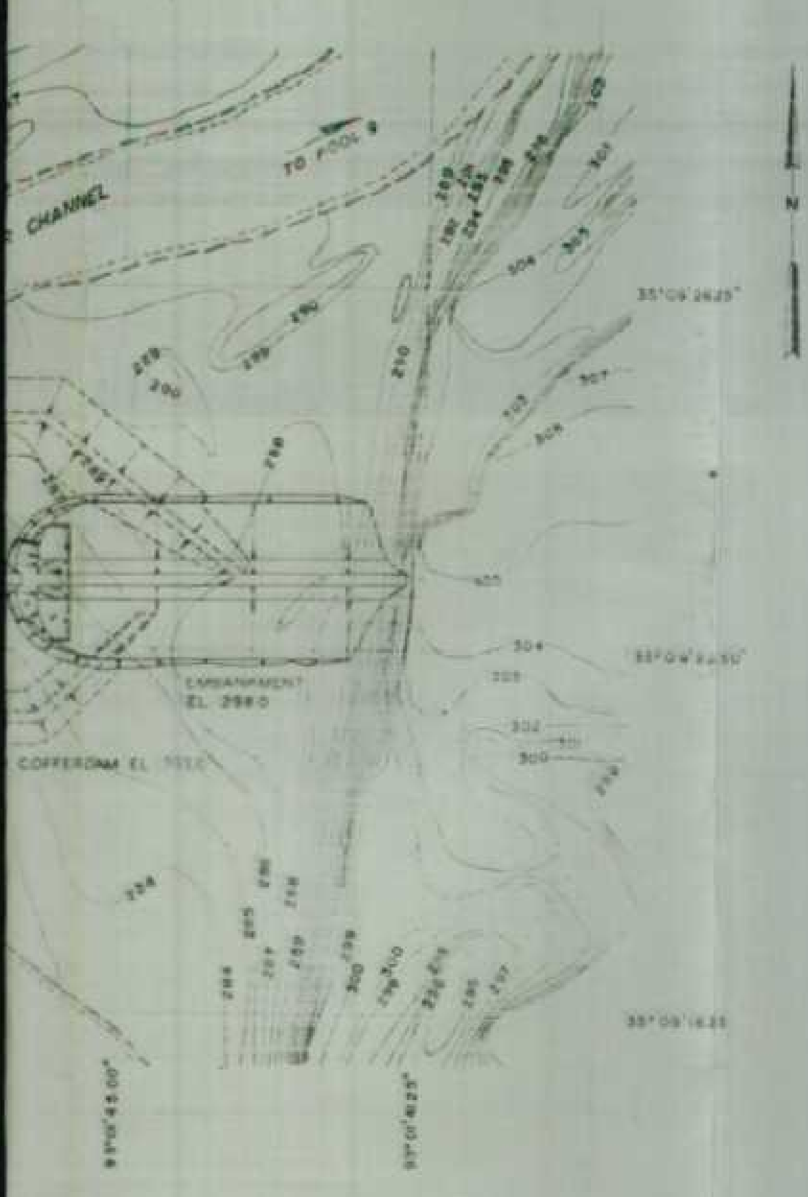
PLAN

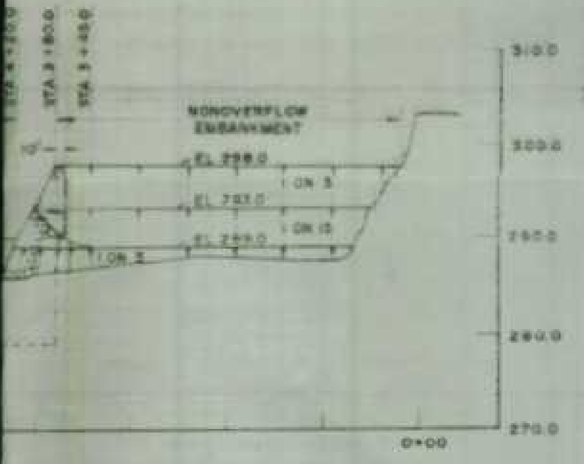
SCALE OF FEET

100' 0 100'



UPSTREAM ELEVATIONS





NOTES:

1. The [illegible] CMP culvert [illegible] construction to drain flows impounded [illegible] the upstream cofferdam [illegible] plugged when the cofferdams [illegible] removed.
2. For Section B-B and Detail "A" see plate 3.

ARKANSAS RIVER AND TRIBUTARIES — ARKANSAS RIVER, ARKANSAS

LOCK AND DAM NO 9
HOLLA BEND REFUGE

FISH AND WILDLIFE STRUCTURE

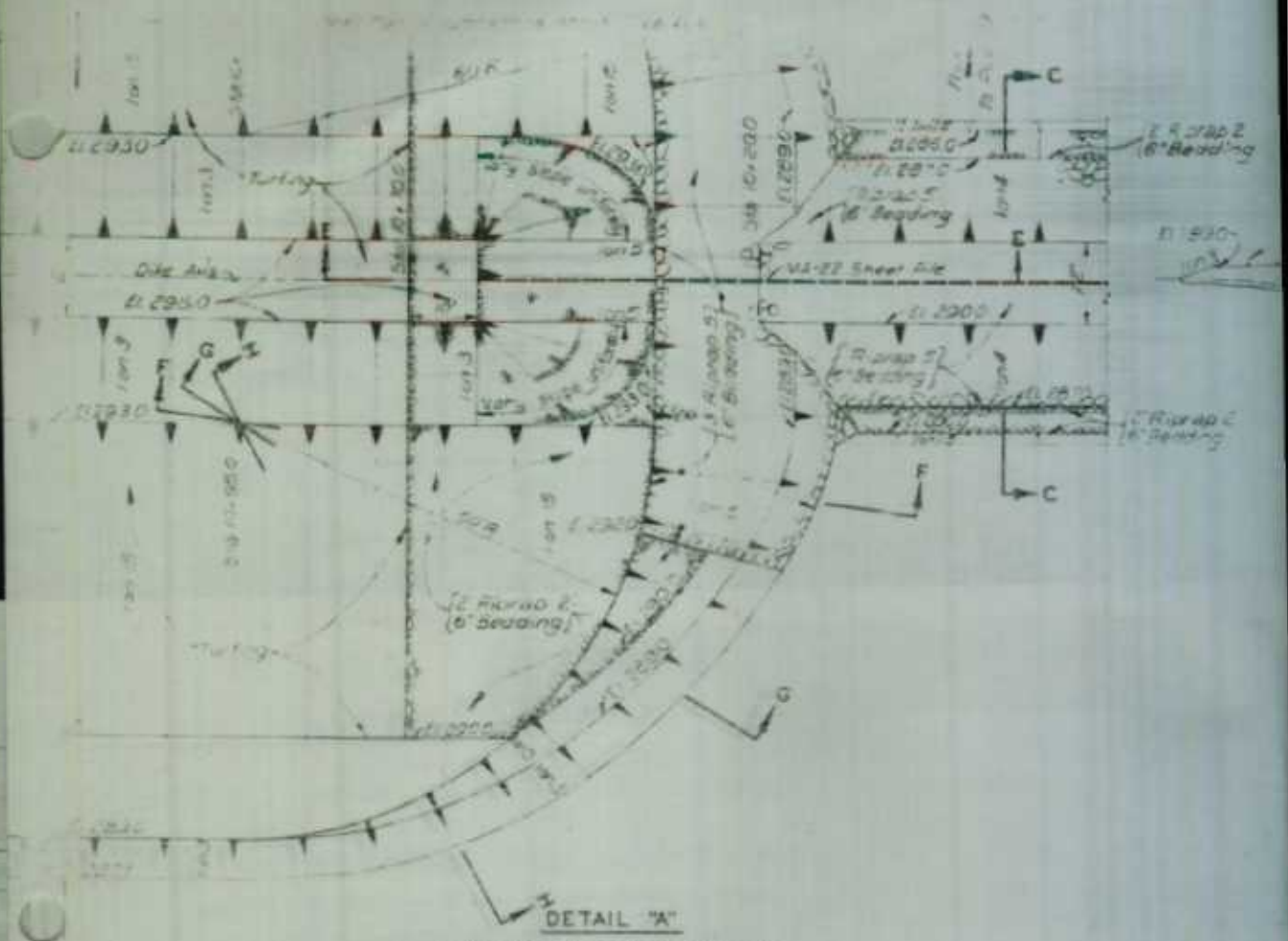
PLAN AND ELEVATION

SCALE AS SHOWN

U.S. ARMY ENGINEER DISTRICT, LITTLE ROCK
LITTLE ROCK ARKANSAS MARCH 1968

DESIGNED: [illegible]
DRAWN: [illegible]
CHECKED: [illegible]
TO ACCOMPANY SUPL NO 2 TO DESIGN MEMO NO [illegible] DATED [illegible]

SERIAL [illegible]
63/182

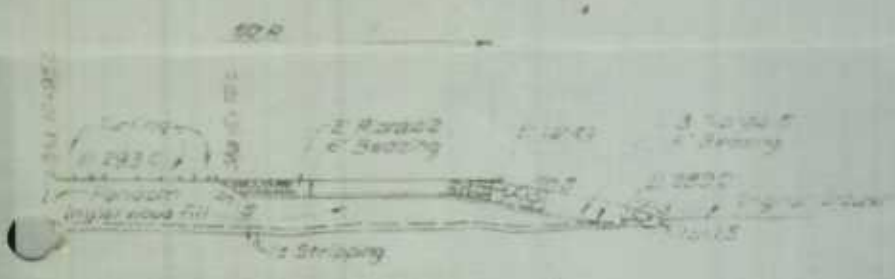


DETAIL "A"

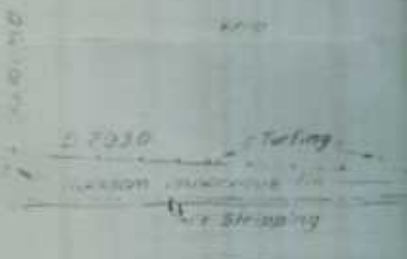
JUNCTION OF OVERFLOW AND NON-OVERFLOW EMBANKMENT

SECTION E-E

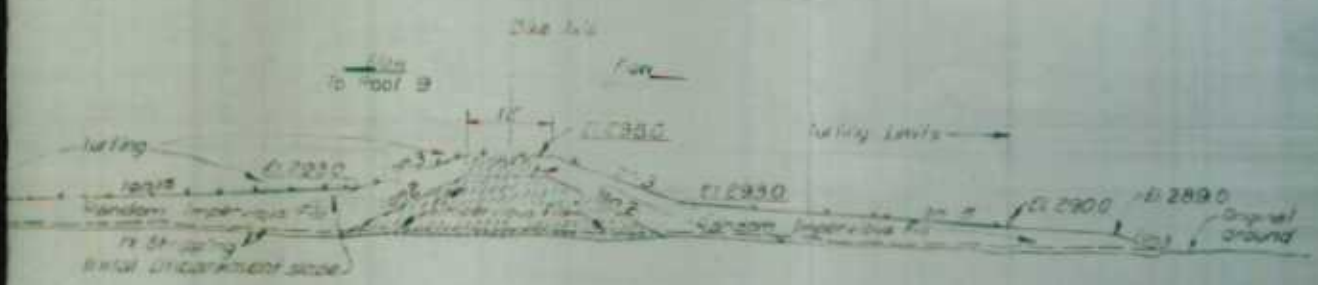
SECTION G-



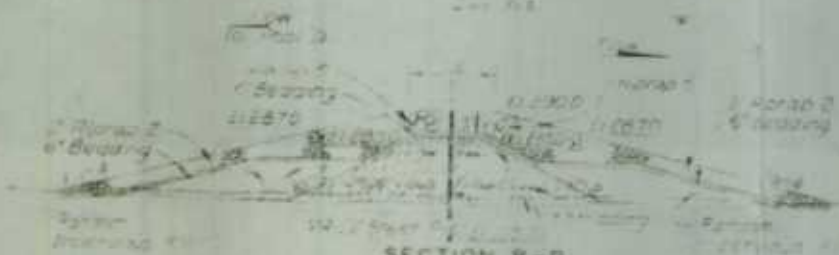
SECTION F-F



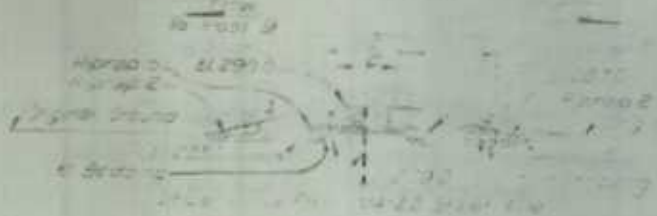
SECTION H-H



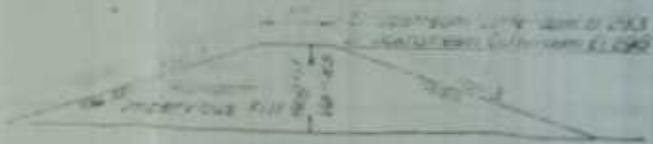
SECTION A-A



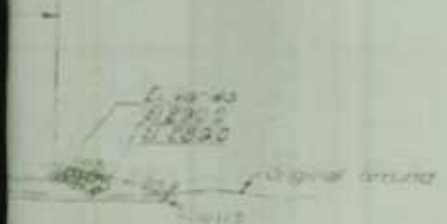
SECTION B-B



SECTION C-C



COFFERDAM



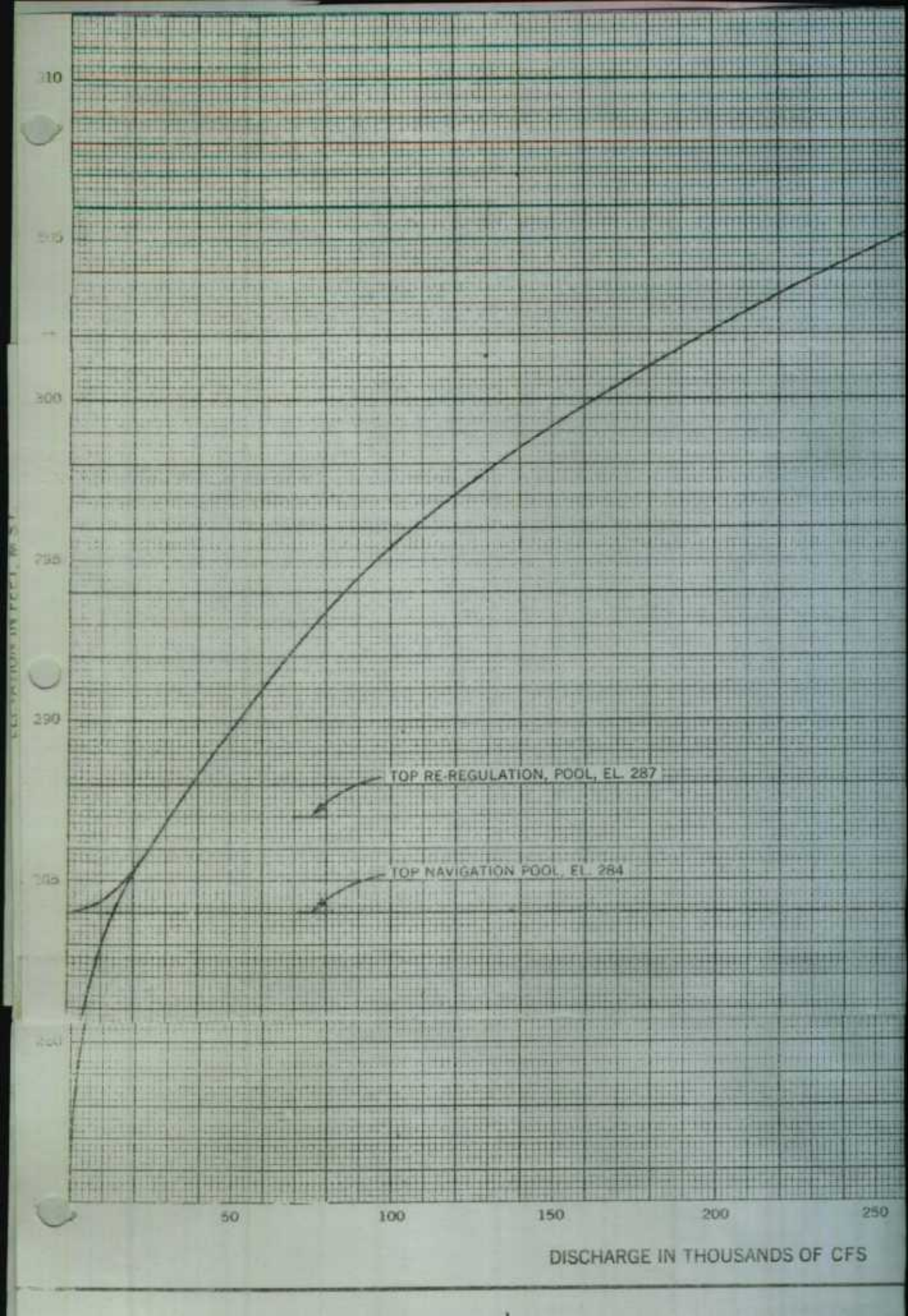
NOTES

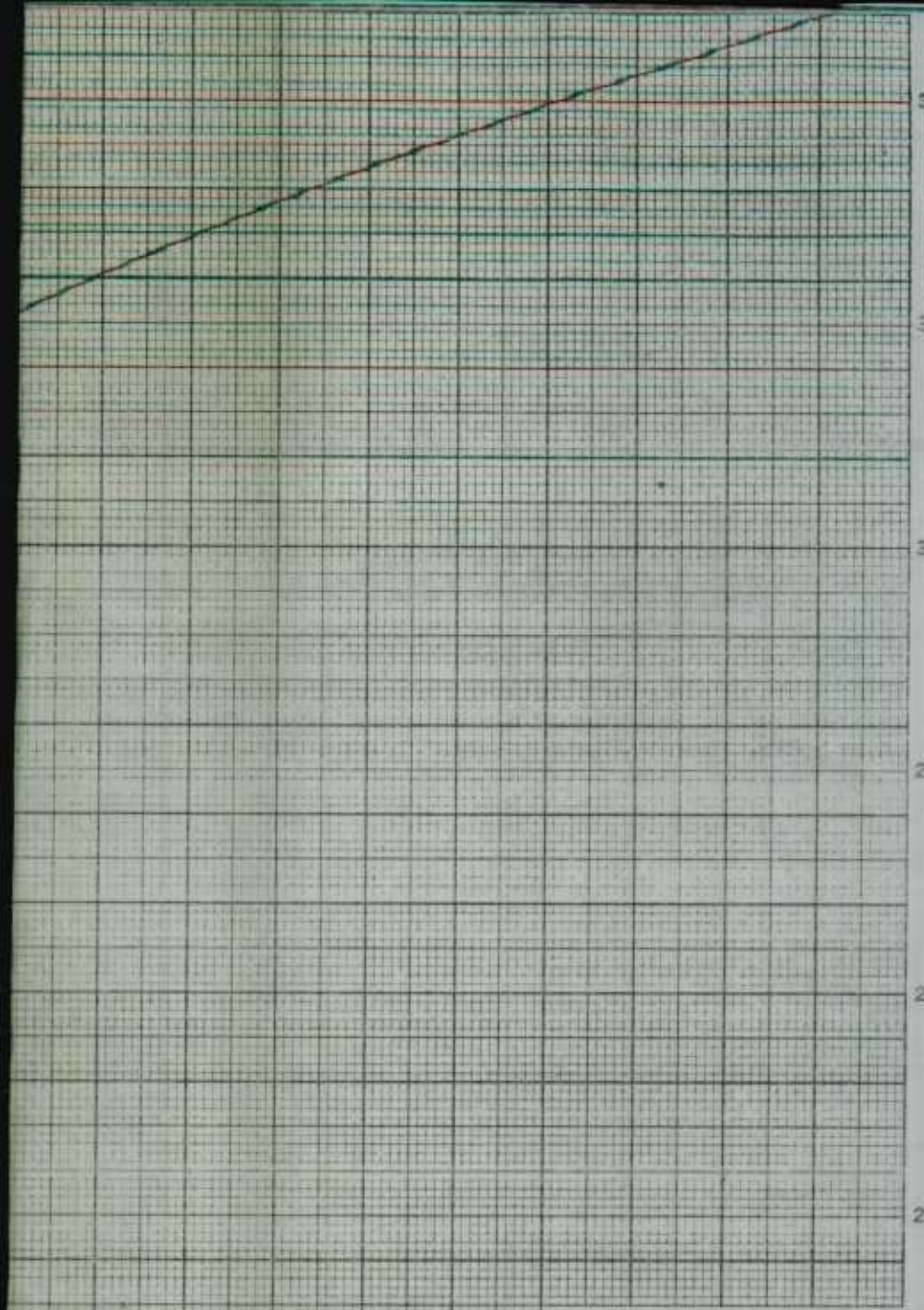
U. S. ARMY ENGINEER DISTRICT, LITTLE ROCK
OFFICE OF THE DISTRICT ENGINEER
LITTLE ROCK, ARKANSAS

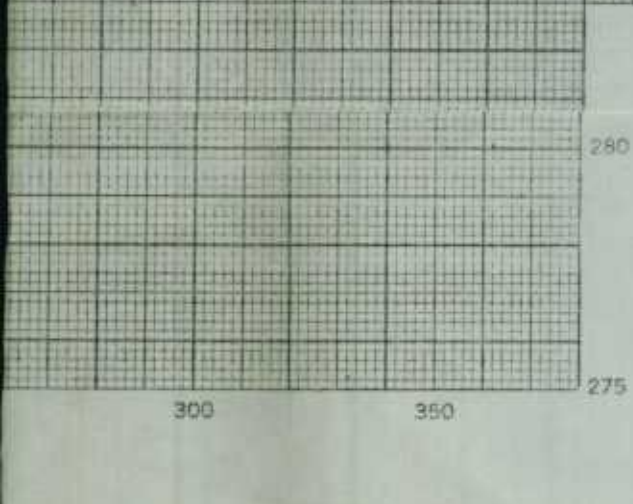
LOCK AND DAM NO. 9
HOLLA BEND REFUGE
FISH AND WILDLIFE
STRUCTURE
DETAILS AND SECTIONS

MARCH 1966

SER 8515-63/183


TOP RE-REGULATION, POOL, EL. 287
TOP NAVIGATION POOL, EL. 284
50
100
150
200
250
DISCHARGE IN THOUSANDS OF CFS





ARKANSAS RIVER AND TRIBUTARIES — ARKANSAS RIVER, ARK.

LOCK AND DAM NO. 9

ARKANSAS RIVER RATING CURVE AT RIVER MILE 241

SCALE: AS SHOWN

U. S. ARMY ENGINEER DISTRICT, LITTLE ROCK
LITTLE ROCK, ARKANSAS, FEBRUARY 1965

DESIGNED: TS — TO ACCOMPANY SUPPLEMENT NO. 2 — SERIAL 6215
DRAWN: HJH — TO GENERAL D. M. NO. 1
CHECKED: WRH — DATED NOVEMBER 1962

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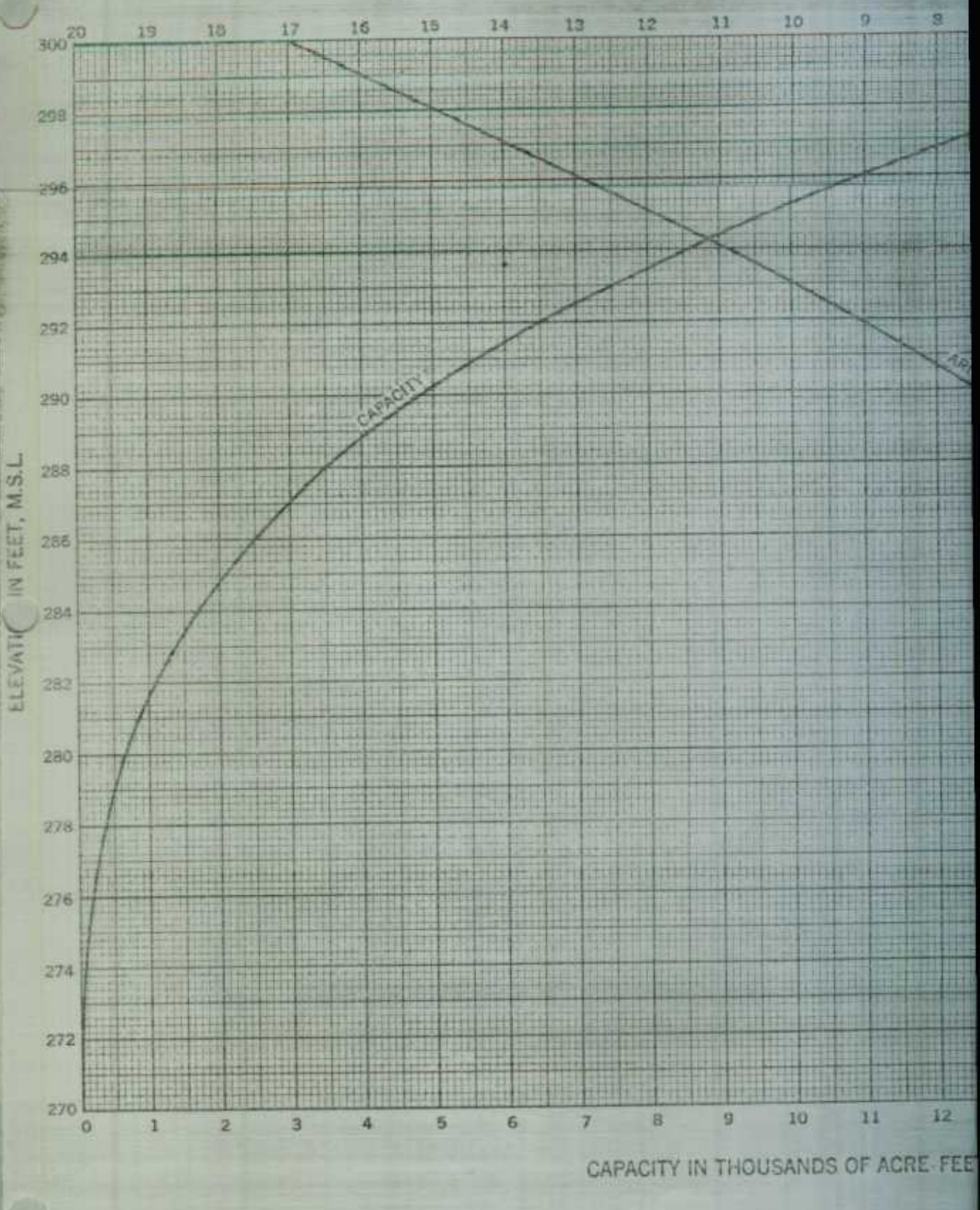
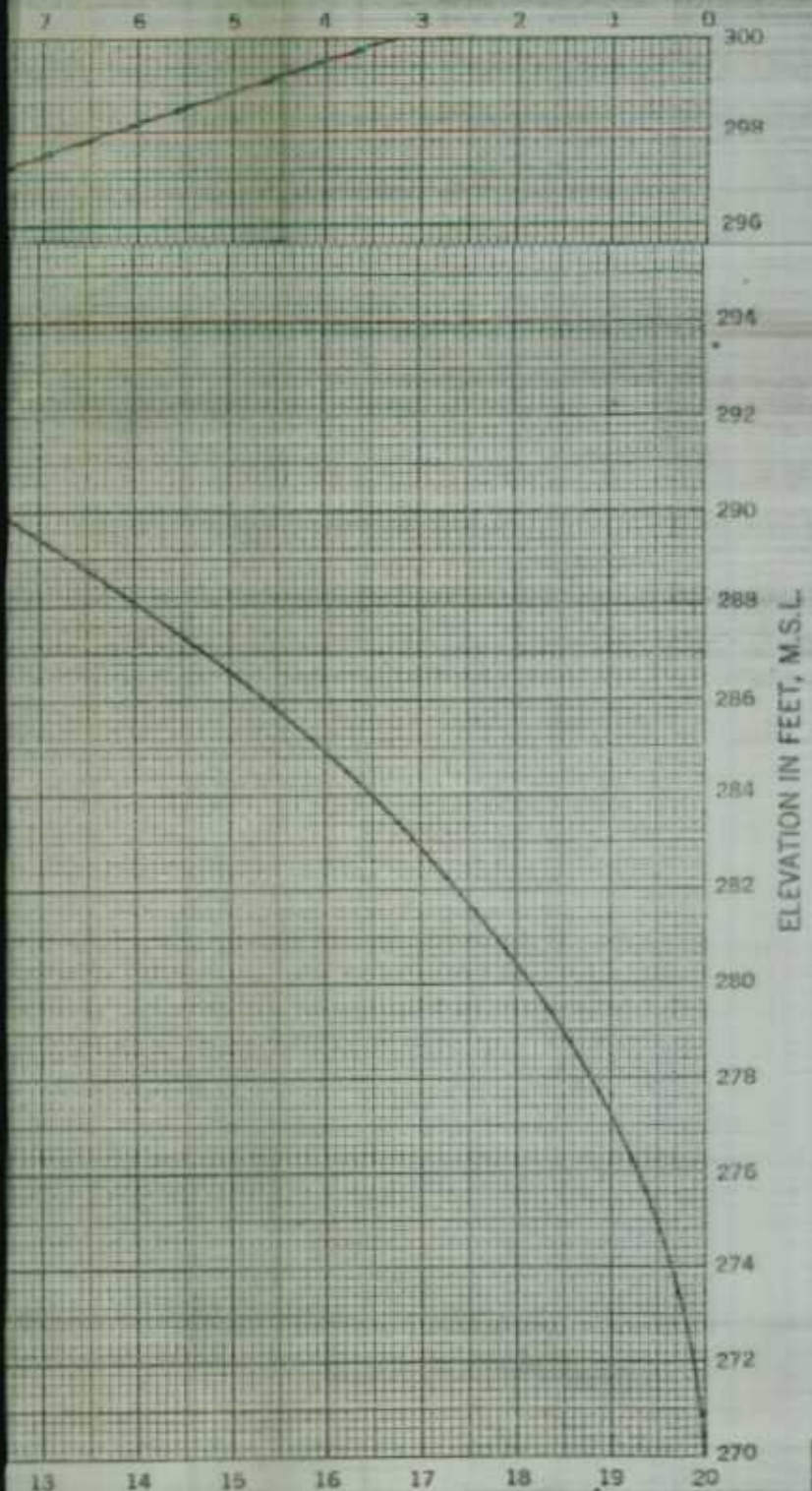
PLATE 4


AREA IN HUNDREDS OF ACRES
20
19
18
17
16
15
14
13
12
11
10
9
8
300
298
296
294
292
290
288
286
284
282
280
278
276
274
272
270
ELEVATION IN FEET, M.S.L.
CAPACITY
0
1
2
3
4
5
6
7
8
9
10
11
12
CAPACITY IN THOUSANDS OF ACRE-FEET



ARKANSAS RIVER AND TRIBUTARIES ARKANSAS RIVER

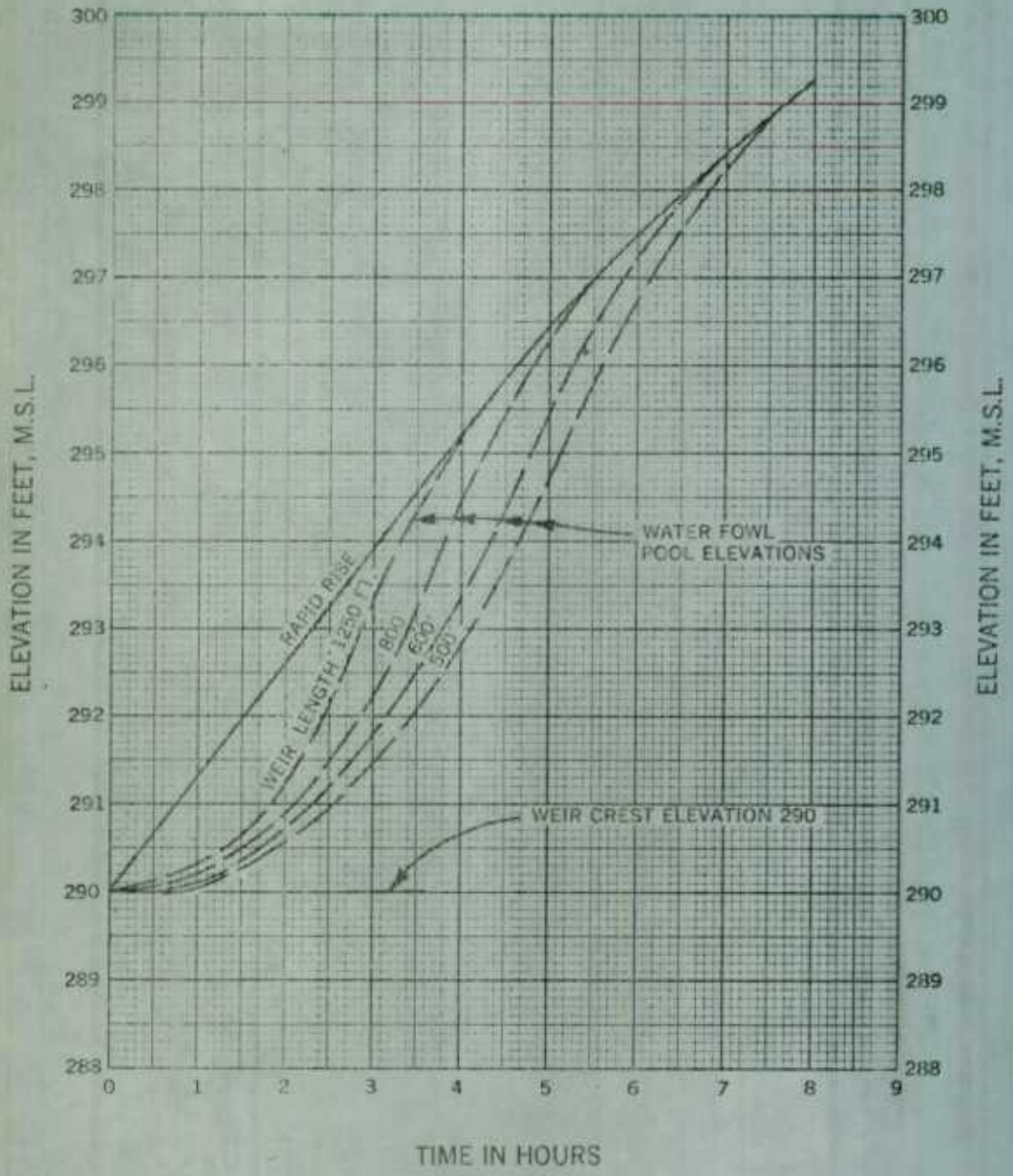
LOCK AND DAM NO. 9
AREA - CAPACITY
WATER FOWL MANAGEMENT POOL
OLD HOLLA BEND

SCALE: AS SHOWN

U. S. ARMY ENGINEER DISTRICT, LITTLE ROCK

LITTLE ROCK, ARKANSAS, FEBRUARY 1968

DESIGNED: DRB TO ACCOMPANY SUPPLEMENT NO. 2 SERIAL
DRAWN: MJH TO GENERAL O. M. NO. 1



ARKANSAS RIVER AND TRIBUTARIES ARKANSAS RIVER, ARK

LOCK AND DAM NO.

ARKANSAS RIVER RAPID RISE AND WATER FOWL POOL STAGE HYDROGRAPHS

SCALE : AS SHOWN

U. S. ARMY ENGINEER DISTRICT, LITTLE ROCK
LITTLE ROCK, ARKANSAS, FEBRUARY, 1968

DESIGNED: DRB TO ACCOMPANY SUPPLEMENT NO. 2 SERIAL 8515
DRAWN: HJH TO GENERAL D. M. NO. 1
CHECKED: WRH DATED NOVEMBER 1968

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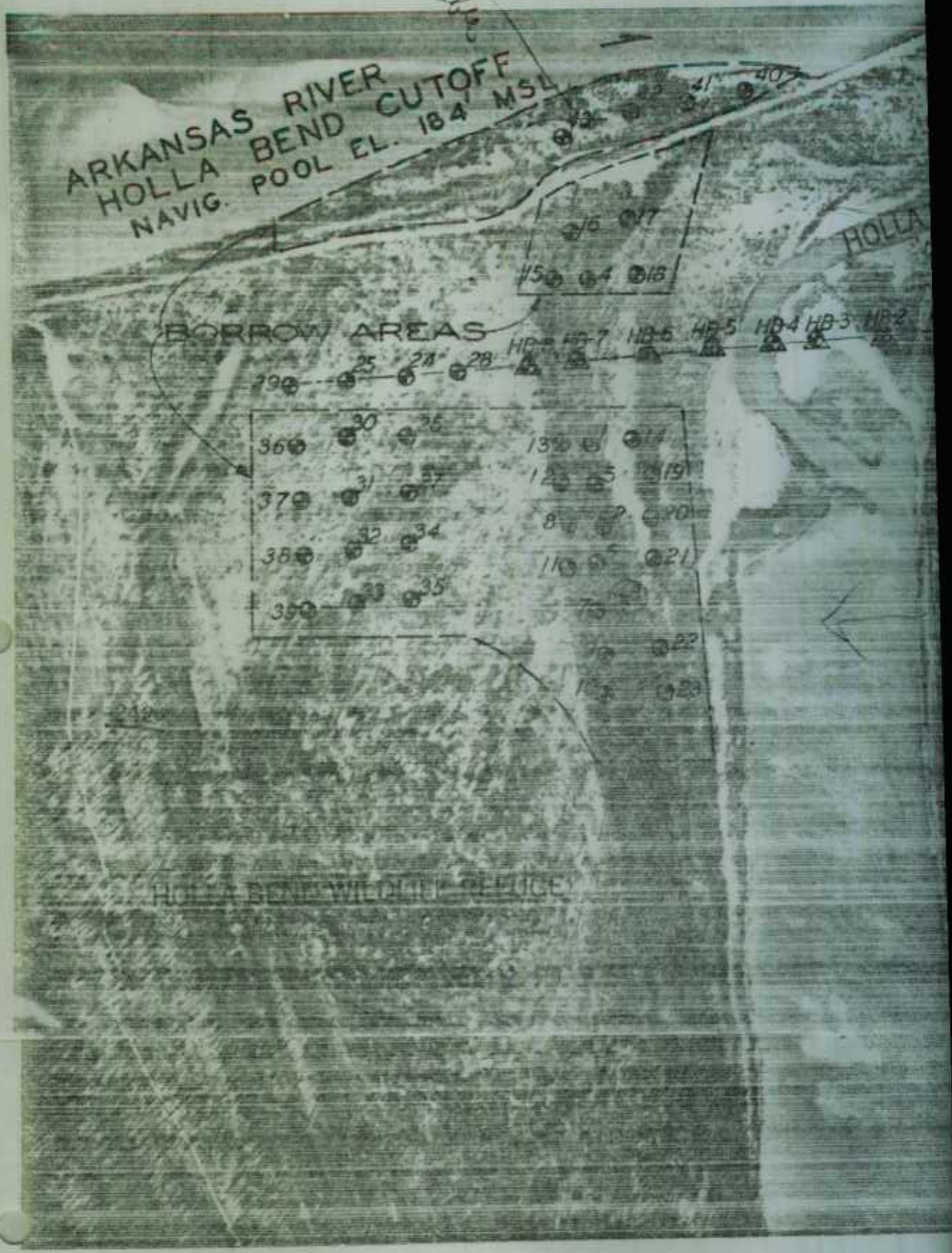
ARKANSAS RIVER
HOLLA BEND CUTOFF
NAVIG. POOL EL. 184' MSL
BORROW AREAS
HB-7
HB-6
HB-5
HB-4
HB-3
HB-2
HOLLA
HOLLA BEND WILDLIFE REFUGE

BORING SCHEDULE	
HOLE NOS	DATE DRILLED
HB-1 THRU HB-8	SEPT 1966
1 THRU 39	OCT 1966
40 THRU 43	MAY 1967

LEGEND:

- COMBINATION AUGER AND DRIVE BORING
- AUGER BORING

NOTE:
FOR SOILS LOGS, SEE PLATES 8 AND 9

SCALE
500' 0' 500'

PLAN OF BORINGS

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PLATE 7


HOLE NO. HB-1

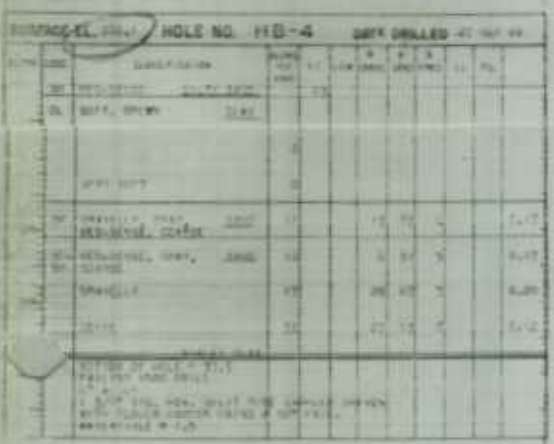

HOLE NO. HB-5

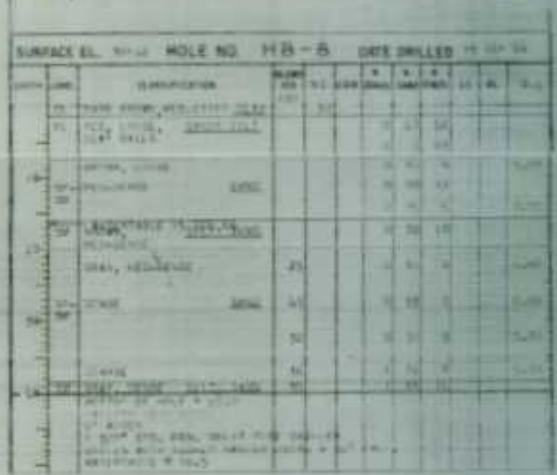

HOLE NO. HB-2


HOLE NO. HB-6


HOLE NO. HB-3


HOLE NO. HB-7


HOLE NO. HB-4


HOLE NO. HB-8

NOTES

1. For soils notes and legend see SOILS LOGS II
2. For locations of borings see PLAN OF BORINGS

U. S. ARMY ENGINEER DISTRICT, LITTLE ROCK
OFFICE OF THE DISTRICT ENGINEER
LITTLE ROCK, ARKANSAS

HOLLA BEND REFUGE
FISH AND WILDLIFE
STRUCTURE
SOILS LOGS I

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SURFACE EL. HOLE NO. 34 DATE DRILLED

SURFACE EL. HOLE NO. 35 DATE DRILLED

SURFACE EL. HOLE NO. 36 DATE DRILLED

SURFACE EL. HOLE NO. 37 DATE DRILLED

SURFACE EL. HOLE NO. 38 DATE DRILLED

SURFACE EL. HOLE NO. 39 DATE DRILLED

SURFACE EL. HOLE NO. 40 DATE DRILLED

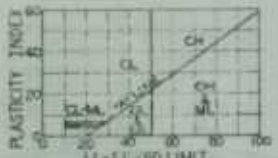
SURFACE EL. HOLE NO. 41 DATE DRILLED

SURFACE EL. HOLE NO. 42 DATE DRILLED

SURFACE EL. HOLE NO. 43 DATE DRILLED

LEGEND

WC - Natural water content in percent dry weight
LL - Liquid limit
PL - Plastic limit
BF or BLOWS PER FOOT - Blows per foot determined with a standard with a standard split spoon sampler (1⅜" I.D. 2"O.D) and a 140 lb. driving hammer with a 30" drop.
D_{10} - That grain diameter in millimeters of which 10% of the soil is finer and 90% coarser than size D_{10}
● - Auger boring
▲ - Auger drive boring
%GRAVEL - Percentage by weight of sample which passes the 3" sieve and is retained on the NO. 4 sieve.
%SAND - Percentage by weight of sample which passes the NO. 4 sieve and is retained on the NO. 200 sieve.
%FINES - Percentage by weight of sample passing the NO. 200 sieve.



PLASTICITY CHART
FOR CLASSIFICATION OF FINE-GRAINED SOILS

UNIFIED SOIL CLASSIFICATION

LETTER SYMBOL	TYPICAL NAMES
SP	SAND, POORLY GRADED, GRAVELLY SAND, LITTLE OR NO FINES
SM	SILTY SAND, SAND-SILT MIXTURES
ML	SILT & VERY FINE SAND, SILTY OR CLAYEY FINE SAND OR CLAYEY SILT WITH SLIGHT PLASTICITY
CL	LEAN CLAY, SANDY CLAY, SILTY CLAY OF LOW TO MEDIUM PLASTICITY
CH	FAT CLAY, INORGANIC CLAY OF HIGH PLASTICITY

NOTES

1. While the borings are representative of subsurface conditions of their respective locations and for their respective vertical reaches, local minor variations in characteristics of the subsurface materials of the region are anticipated.
2. Water table elevations shown on the borings represent water levels determined on the dates shown.
3. For boring locations see PLAN OF BORINGS.

U. S. ARMY ENGINEER DISTRICT, LITTLE ROCK
OFFICE OF THE DISTRICT ENGINEER
LITTLE ROCK, ARKANSAS

HOLLA BEND REFUGE
FISH AND WILDLIFE
STRUCTURE
SOILS LOGS II

AUGUST 1968

63,18