DEVELOPING SATISFACTORY NAVIGATION CONDITIONS AT THE APPROACH TO COLUMBUS LOCK

by

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INTRODUCTION

The Tennessee-Tombigbee Waterway project was first authorized in 1946 by the River and Harbor Act. When completed this waterway will link the Tennessee River system with the Gulf coastal regions (Figure 1). It will enable barge traffic to move directly from the Mobile, Alabama area up to the Tennessee River, thereby cutting hundreds of miles off the route now used, which is up the Mississippi and Ohio Rivers and back into the Tennessee River. This waterway will also lessen the heavy barge traffic now using the Mississippi and Ohio. The main justification of the Tenn-Tom project is to reduce transportation cost for transporting commodities from the Gulf coastal areas up to the Tennessee River System. Other benefits will be those pertaining to recreation such as fishing, boating, skiing, swimming, etc.

The project is divided into three sections consisting of a river section, a canal section, and a divide section. The river section will consist of a 173 mile long reach of river extending up the Tombigbee River from Demopolis, Alabama, where the Warrior River flows into the Tombigbee, to a point just north of Amory, Mississippi. Work in this section will involve straightening the river channel and building conventional locks and dams near Gainesville and Aliceville, Alabama, and Columbus and Aberdeen, Mississippi. The canal section will consist of a 45.6 mile long canal above the river section up to Bay Springs Lock and Dam in the Mackey's Creek area. Five locks and dams will be built in this section. The divide section will consist of a 39.3 mile long canal that will extend from Bay Springs, Mississippi, to the Yellow Creek arm of Pickwick Lake on the Tennessee River near the common boundary of Mississippi, Alabama, and Tennessee. The ten locks built in these three sections will provide a total lift of 341 feet to overcome the difference in elevation between Demopolis Lake on the Tombigbee River and Pickwick Lake on the Tennessee River.

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PURPOSE AND SCOPE OF MODEL STUDY

Although the original design of Columbus Lock and Dam was based on sound theoritical design practice and experience with similar structures, it was adventageous to test the design with a model. The reason for this is navigation conditions vary with location and flow conditions upstream and downstream of a structure, and an analytical study to determine the hydraulic effects that can be expected to result with a particular design is very difficult and inconclusive. Conditions in the general area of the Columbus Lock and Dam were especially complicated by the location of the approach canal with respect to the river channel, overbank flow, and flow from the Tibbee River. For these reasons a model study was considered necessary to investigate the conditions that could be expected with the proposed design and to make modifications required to ensure satisfactory navigation conditions at the approach to Columbus Lock.

MODEL DESCRIPTION

The model reproduced about 4.5 miles of the Tombigbee River extending from just downstream of the lock and dam to just upstream of the entrance to the lock approach canal. The location of the lock and dam, which was just downstream from the mouth of the Tibbee River near Plymouth Bluff, Mississippi, and the approach canal were fixed at the time the model study was begun. The model was a fixed bed model molded to sheet metal templates.

The lock and spillway were constructed of sheet metal (Figure 2). The lock had a clear chamber dimension of 110 feet wide by 600 feet long with a 600-foot long ported upper guardwall and a 600-foot long non-ported lower guardwall. The top of the lock walls were at elevation 173 MSL*. The spillway contained five 60-foot wide gatebays and six eight-foot wide piers with gatesills at elevation 138. An abutment wall 125 feet long with top elevation 173 connected the lock and spillway together.

SCALE RATIO

The model was built to an undistorted linear scale ratio of 1:120 model to prototype to obtain accurate reproduction of velocities, cross currents, and eddies which would affect navigation. Some of the other scale relations were as follows:

Area	1:14,400
Velocity	1:10.95
Time	1:10.95
Discharge	1:157,743
Roughness (Manning's n)	1:2.22

These ratios were used to change model information into prototype information and vice versa.

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* MSL is referred to as mean sea level.

REPRODUCTION OF RIVER CONDITIONS

The amount of water entering the model was controlled and measured at the upper end of the model by means of valves and venturi meters. Water surface elevations were measured by means of piezometer gages located in the model channel. These gages were connected to a centrally located gage pit. The spillway gates were used to set the upper pool stages when a controlled river flow was tested, while for an open river flow a tailgate located at the lower end of the model controlled the tailwater elevations. Flow distribution along the length of the dam was based on velocity measurements through each gatebay.

Velocities and current directions were obtained by using small weighted wood floats which drafted the same amount of water as a loaded barge. Dye and confetti were used to obtain a basic idea of how the surface and bottom currents were behaving for different flow conditions. Remote controlled model towboats were used to determine and demonstrate the effects of currents around and near the approach to the lock.

TESTING

No serious problems with the downstream side of the lock and dam were encountered in the preliminary tests, but these tests did reveal some trouble areas on the upstream side of the structure. These problems were dealt with by making modifications to the original design or plan until favorable results were obtained.

The original design consisted of a non-navigable gated spillway and a lock located in a cut-off canal in the left overbank near Plymouth Bluff (Figure 3). The lock was located on the right side of the structures. An approach canal to the lock was excavated for a distance of 8,400 feet extending from the lock's upper guardwall across the old Tombigbee River channel and across the Tibbee River channel and then tying into the Tombigbee River further upstream. The bottom width of the canal was 300 feet at an elevation of 150 MSL. The lower lock approach canal was excavated to elevation 123 with improvement to the downstream river channel to provide a bottom width of 300 feet.

Navigation during the higher flows was found to be very difficult in three areas upstream of the lock. These were as follows:

a. In the entrance to the approach canal.

b. Where the approach canal crossed the Tibbee River channel.

c. At the upper end of the lock's upper guardwall.

Several plans were tested in an effort to correct the above mentioned problems. They were similar to the original plan except for dikes, fill materials, and guardcells added in various places above the lock. Of the plans tested the one which yielded the best results was plan D-2 (Figure 4).

Plan D-2 varied from the original plan in the following ways:

a. The landfill on the right overbank adjacent to the lock was formed into a straight line from the lock upstream to the access road.

b. The Tombigbee River channel to the right of the lock approach channel was filled to elevation 152.

c. Two vane dikes were placed on the right bank of the canal about 1,386 feet and 2,054 feet upstream from the axis of the dam with the upstream ends of the dikes angled away from the canal.

d. Another dike was placed along the left bank of the canal extending from the Tombigbee River channel upstream across the Tibbee River channel.

e. A rock fill was placed between the lock and the gated section of the dam just upstream of the fixed weir to about elevation 170 to guide the flow from along the lock wall into the gatebay nearest the lock.

f. Four 25-foot cells spaced 245 feet center to center were placed above and in line with the end of the guardwall. Also a rock-filled dike was placed to the left of the cells.

g. The right bank of the approach channel from the lock to the Tombigbee River channel was angled landward.

h. A dike was built extending from the Tibbee River on the right side of the canal upstream to the Tombigbee.

i. A fill to elevation 152 was placed across the Tibbee River channel just upstream of the lock approach canal.

j. A short dike was placed on the right bank of the canal just downstream of the Tibbee River.

There was also another plan tested during the model tests. Plan E involved investigating the possibility of barge traffic moving up the Tibbee River (Figure 5). The main difference between it and Plan D-2 was at the crossing of the Tibbee and the approach canal.

DISCUSSION

Results of the investigations revealed that navigation conditions in the upper approach could be made satisfactory with proper modifications. Even with the modifications developed, two-way navigation in the upper

approach to the lock could be difficult and hazardous during high flows with a flood on the Tibbee River and little or no flow in the Tombigbee River. It was found that satisfactory navigation conditions into and out of the lower reach of the Tibbee River could be developed for limited size tows, but conditions would tend to be difficult and hazardous during the higher flows.

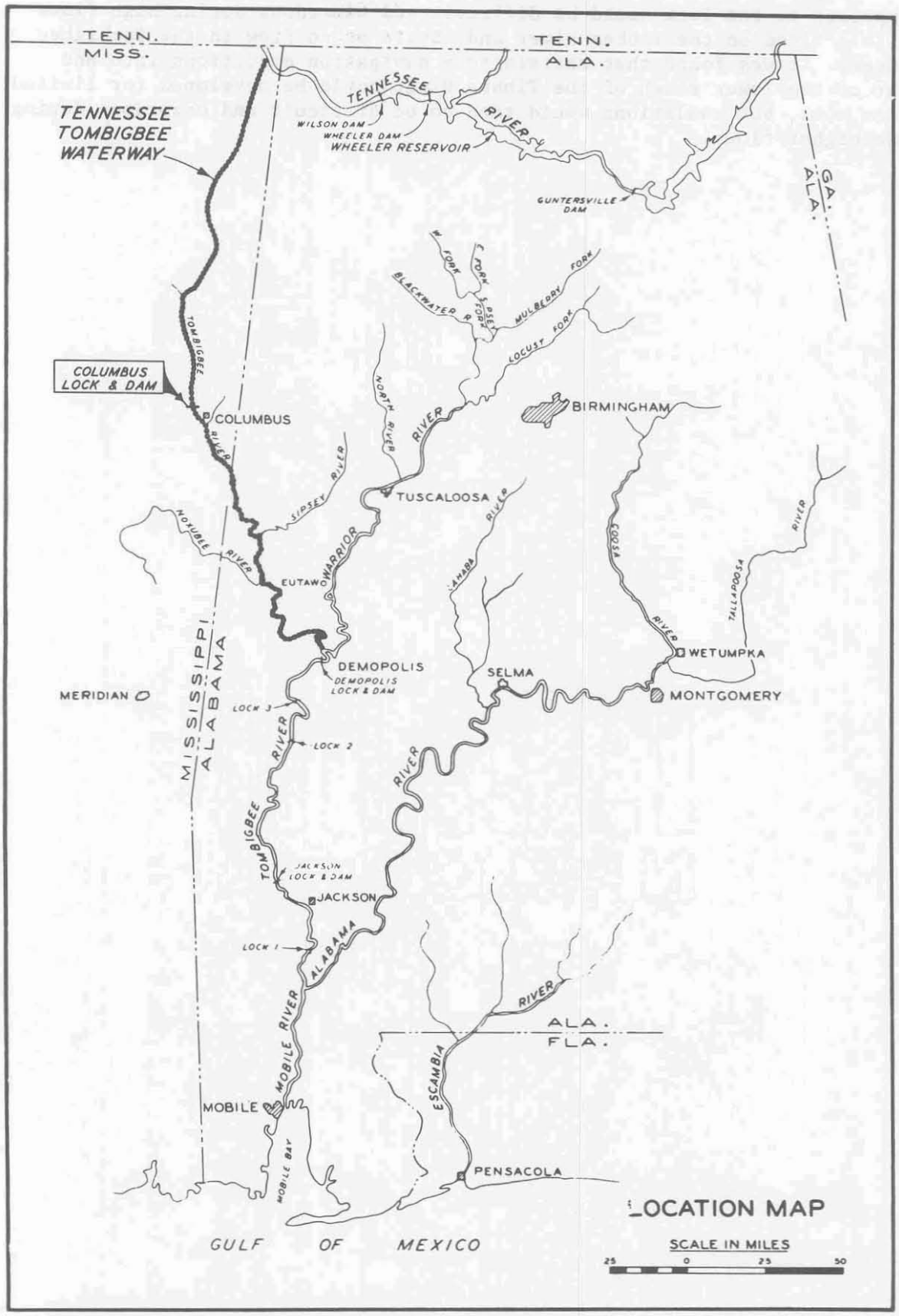
TENN.
MISS.
TENN.
ALA.
TENNESSEE
TOMBIGBEE
WATERWAY
TENNESSEE
RIVER
WILSON DAM
WHEELER DAM
WHEELER RESERVOIR
GUNTERSVILLE DAM
GA.
ALA.
TOMBIGBEE
COLUMBUS
LOCK & DAM
COLUMBUS
TOMBIGBEE RIVER
SIPSEY RIVER
NORTH RIVER
RIVER
BLACKWATER R.
W. FORK
E. FORK
S. FORK
MULBERRY FORK
LOCUST FORK
BIRMINGHAM
TUSCALOOSA
NOXUBEE RIVER
EUTAW
WARRIOR
RIVER
CAHABA
COOSA
RIVER
TALLAPOOSA
RIVER
WETUMPKA
MISSISSIPPI
ALABAMA
DEMOPOLIS
DEMOPOLIS
LOCK & DAM
SELMA
MONTGOMERY
MERIDIAN
LOCK 3
LOCK 2
TOMBIGBEE
RIVER
ALABAMA
RIVER
JACKSON
LOCK & DAM
JACKSON
LOCK 1
MOBILE RIVER
ALA.
FLA.
ESCAMBIA
RIVER
MOBILE
MOBILE BAY
PENSACOLA
GULF OF MEXICO
LOCATION MAP
SCALE IN MILES
25 0 25 50

Figure 1

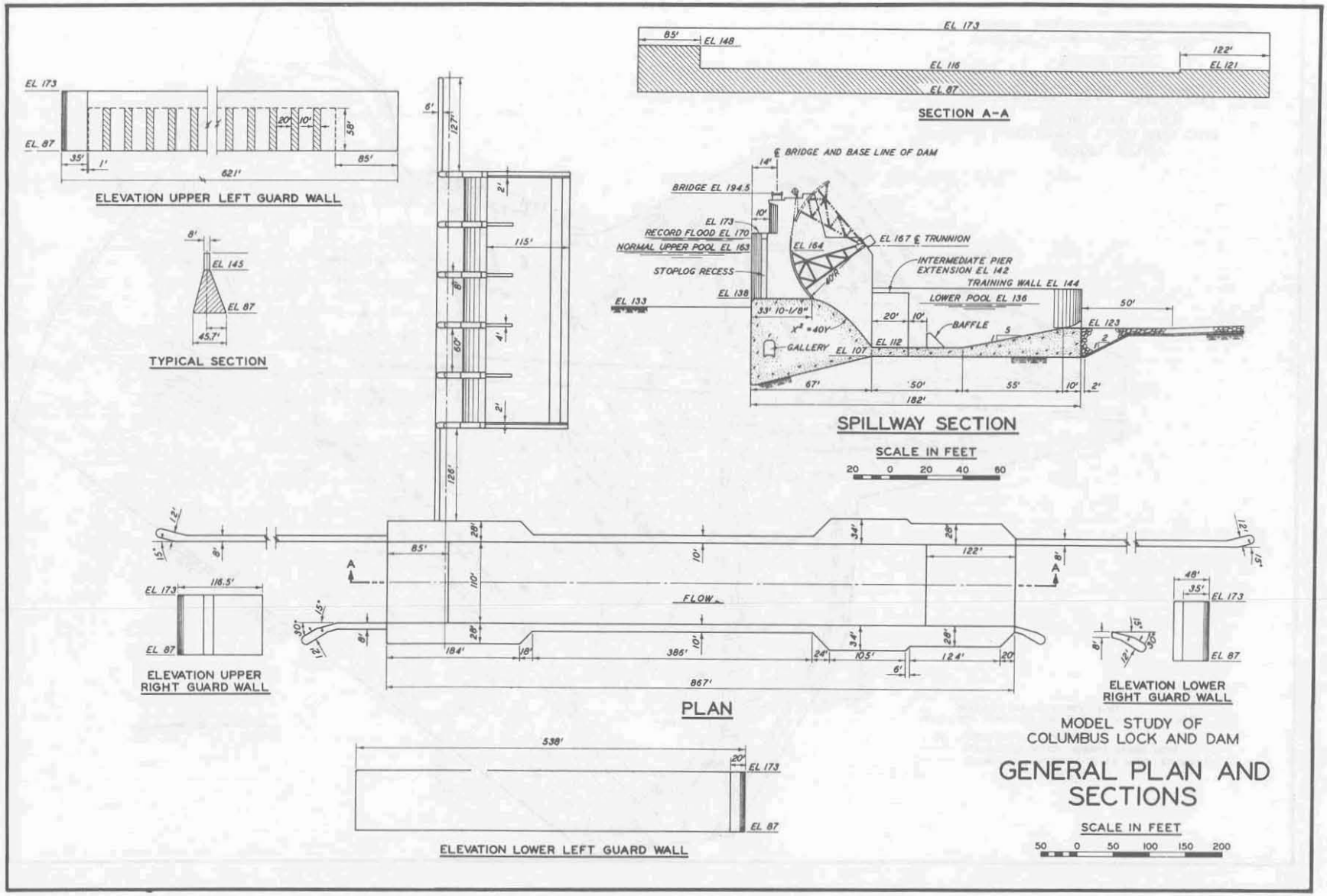
EL 173
EL 87
35'
1'
621'
85'
ELEVATION UPPER LEFT GUARD WALL
8'
EL 145
EL 87
45.7'
TYPICAL SECTION
EL 173
85'
EL 148
EL 116
EL 87
122'
EL 121
SECTION A-A
℄ BRIDGE AND BASE LINE OF DAM
BRIDGE EL 194.5
EL 173
RECORD FLOOD EL 170
NORMAL UPPER POOL EL 163
STOPLOG RECESS
EL 138
EL 133
EL 167 ℄ TRUNNION
EL 164
INTERMEDIATE PIER EXTENSION EL 142
TRAINING WALL EL 144
LOWER POOL EL 136
33' 10-1/8"
X² = 40Y
GALLERY
EL 107
EL 112
BAFFLE
EL 123
67'
50'
55'
182'
SPILLWAY SECTION
SCALE IN FEET
20 0 20 40 60
FLOW
867'
PLAN
EL 173
EL 87
116.5'
ELEVATION UPPER RIGHT GUARD WALL
538'
20'
ELEVATION LOWER LEFT GUARD WALL
48'
35'
ELEVATION LOWER RIGHT GUARD WALL
MODEL STUDY OF
COLUMBUS LOCK AND DAM
GENERAL PLAN AND SECTIONS
SCALE IN FEET
50 0 50 100 150 200

Figure 2


LEGEND
APPROXIMATE NORMAL UPPER POOL (EL 163.0)
ELEVATIONS BELOW NORMAL UPPER POOL
MODEL GAGE LOCATION
NOTE: ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO MEAN SEA LEVEL
MODEL STUDY
COLUMBUS LOCK AND DAM
TOMBIGBEE RIVER
ORIGINAL DESIGN
SCALES IN FEET
PROTOTYPE
MODEL
MODEL LIMITS
MODEL LIMITS
EXCAVATE TO EL 133
EXCAVATE TO EL 123.0
EXCAVATE TO EL 150.0
EL 200.0
EL 188.0
EL 157.0
STA 0+00
STA 14+30
PLYMOUTH BLUFF
TOMBIGBEE RIVER
N
N 1,410,000
E 608,000
N 1,407,000
E 613,000
N 1,411,000
E 601,000
N 1,369,000
E 603,000

Figure 3

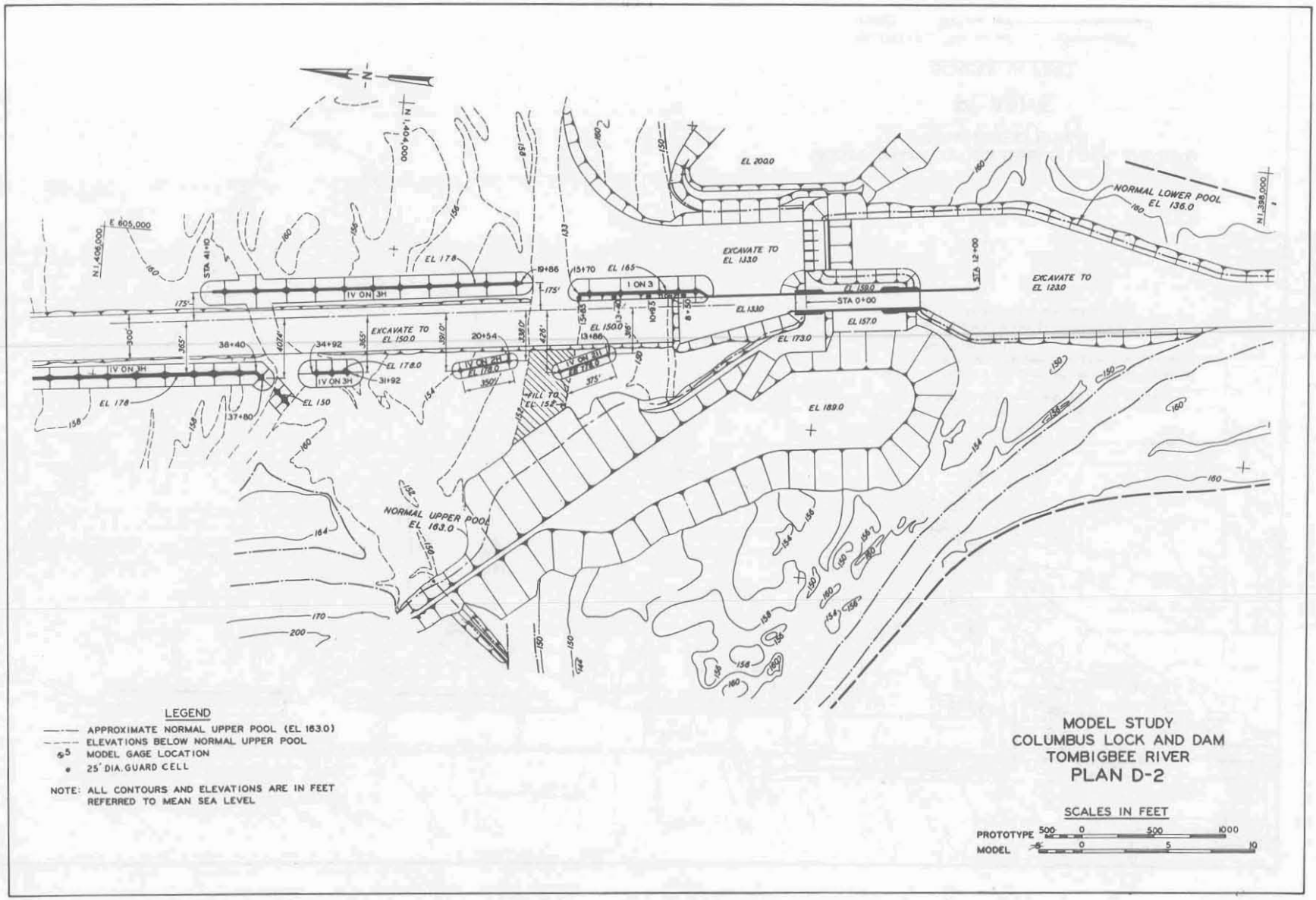
N
N 1,404,000
E 805,000
N 1,406,000
STA 41+00
EL 178
19+86
15+70
EL 165
1 ON 3
EL 200.0
NORMAL LOWER POOL
EL 136.0
N 1,398,000
EXCAVATE TO
EL 133.0
STA 12+00
EXCAVATE TO
EL 123.0
EL 138.0
STA 0+00
EL 157.0
EL 133.0
EL 173.0
EL 189.0
1V ON 3H
38+40
34+92
EXCAVATE TO
EL 150.0
EL 178.0
31+92
EL 150
20+54
1V ON 2H
EL 178.0
350'
FILL TO
EL. 152
EL 150.0
13+86
1V ON 3H
EL 178.0
375'
NORMAL UPPER POOL
EL 183.0
37+80
EL 178
LEGEND
APPROXIMATE NORMAL UPPER POOL (EL 183.0)
ELEVATIONS BELOW NORMAL UPPER POOL
MODEL GAGE LOCATION
25' DIA. GUARD CELL
NOTE: ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO MEAN SEA LEVEL
MODEL STUDY
COLUMBUS LOCK AND DAM
TOMBIGBEE RIVER
PLAN D-2
SCALES IN FEET
PROTOTYPE 500 0 500 1000
MODEL 0 5 10

Figure 4

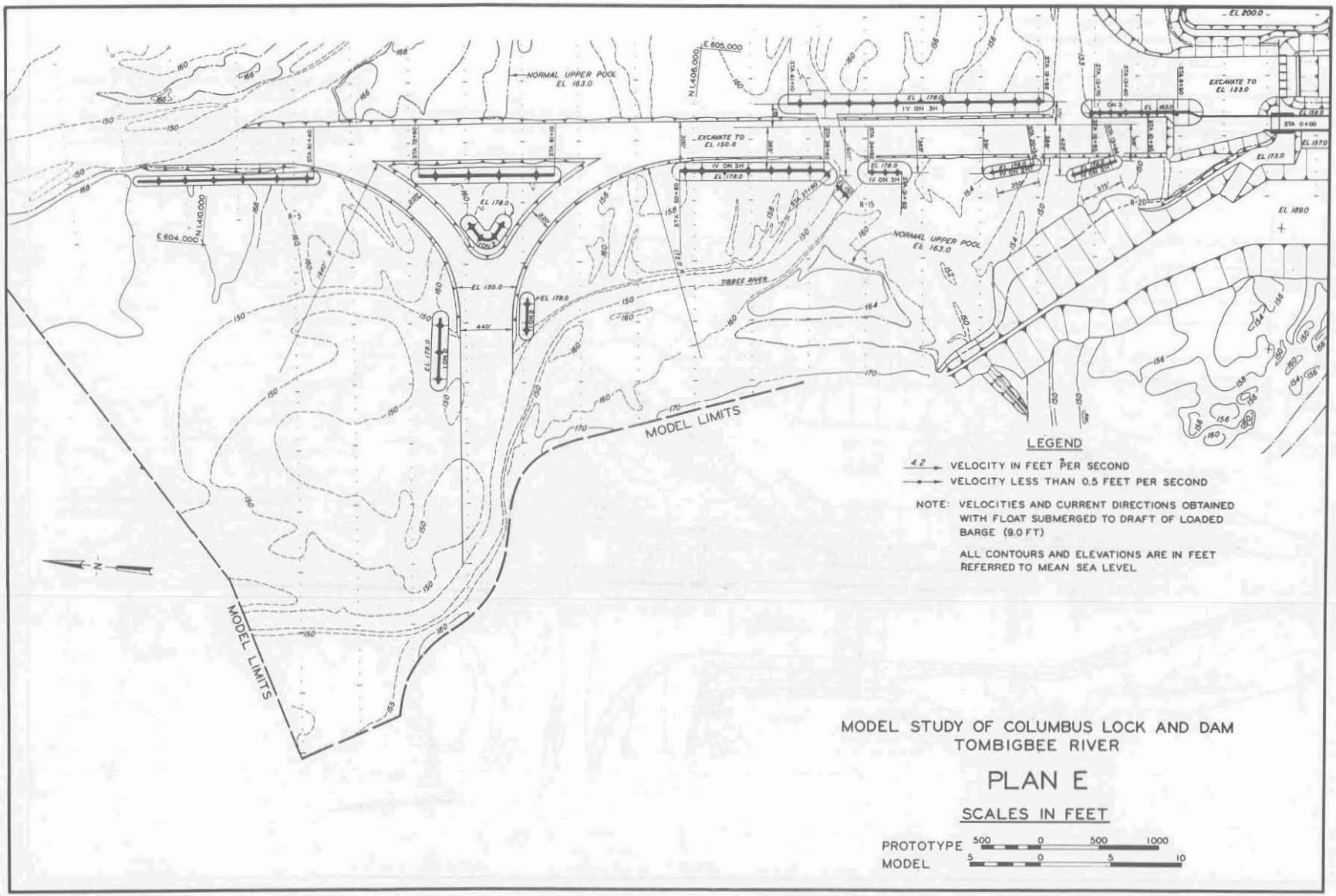
NORMAL UPPER POOL EL 163.0
E 605,000
N 1,406,000
EXCAVATE TO EL 150.0
EXCAVATE TO EL 143.0
EL 178.0
1V ON 3H
EL 200.0
EL 189.0
EL 173.0
EL 137.0
STA 0+00
E 604,000
N 1,410,000
TIBBEE RIVER
EL 150.0
440'
MODEL LIMITS
MODEL LIMITS
LEGEND
4.2 VELOCITY IN FEET PER SECOND
VELOCITY LESS THAN 0.5 FEET PER SECOND
NOTE: VELOCITIES AND CURRENT DIRECTIONS OBTAINED WITH FLOAT SUBMERGED TO DRAFT OF LOADED BARGE (9.0 FT)
ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO MEAN SEA LEVEL
MODEL STUDY OF COLUMBUS LOCK AND DAM
TOMBIGBEE RIVER
PLAN E
SCALES IN FEET
PROTOTYPE 500 0 500 1000
MODEL 5 0 5 10

Figure 5