R-98-04

PHYSICAL MODEL STUDIES OF THE GCID PUMPING PLANT FISH SCREEN STRUCTURE

Report No. 3

1:16 Scale Model Investigations: Alternative D

April 1998

U.S. DEPARTMENT OF THE INTERIOR
Bureau of Reclamation
Technical Service Center
Water Resources Research Laboratory

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1:16 Scale Model Investigations: Alternative D

by
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UNITED STATES DEPARTMENT OF THE INTERIOR ★ BUREAU OF RECLAMATION

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INTRODUCTION

The Glenn-Colusa Irrigation District (GCID) Pumping Plant is located in north-central California, approximately 100 miles north of Sacramento, on the Sacramento River (figure 1). The pumping plant exports river water to the west side of the Sacramento River Valley for irrigation. The diversion and pumping plant are located on an oxbow side channel that carries a portion of the river around Montgomery Island.

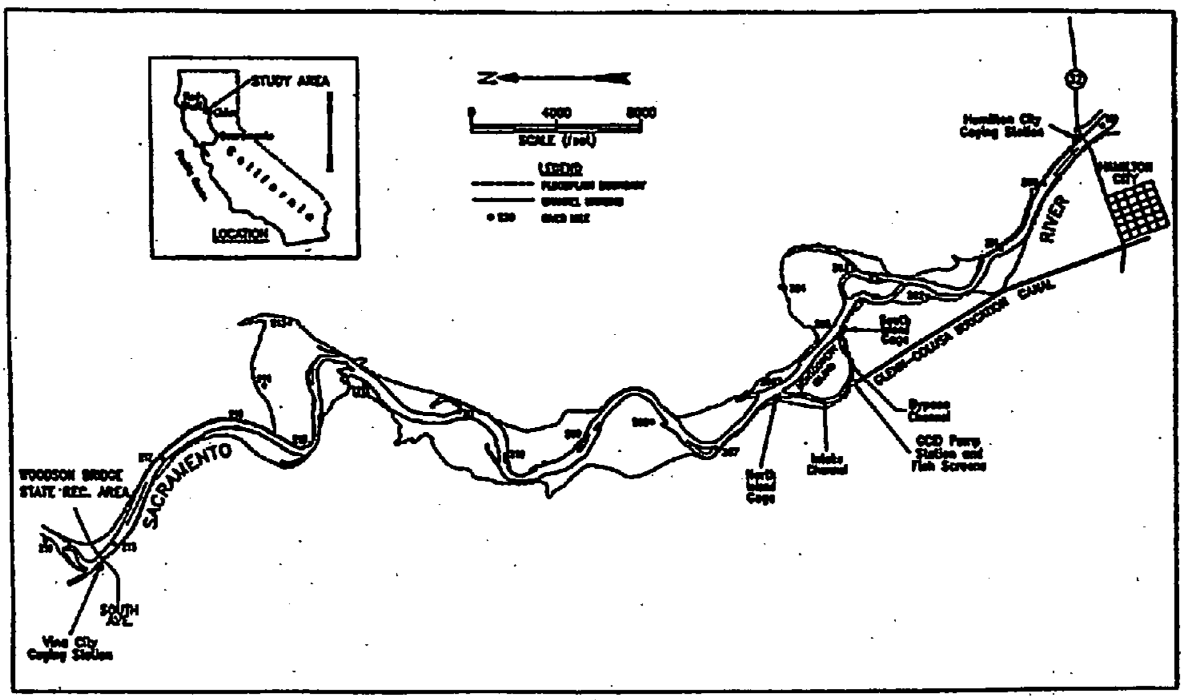


Figure 1.—General location map of GCID pumping plant and existing fish screen facilities.

This report is the third in a series of progress reports presenting data from physical model studies on fish screen alternatives for GCID. Progress report Nos. 1 and 2 covered 1:30 scale model studies. Report No. 1 (Mefford and Kubitschek 1997) covered studies of the initial design for the Alternative D linear screen. Report No. 2 (Mefford and Kubitschek 1998) covered model tests of screen concept Alternative A, a multiple-bay "V" shaped screen design. In 1996, a Technical Advisory Group (TAG) for the project recommended the Alternative D screen concept be chosen for final design (figure 2). Following the TAG recommendation, a 1:16 scale model of the linear screen concept was constructed in the Water Resources Research Laboratory. The larger model was used to further investigate flow conditions as affected by water surface differential across Montgomery Island, upstream and downstream channel transitions, screen alignment to the channel, fish bypasses, and screen baffling. The project may

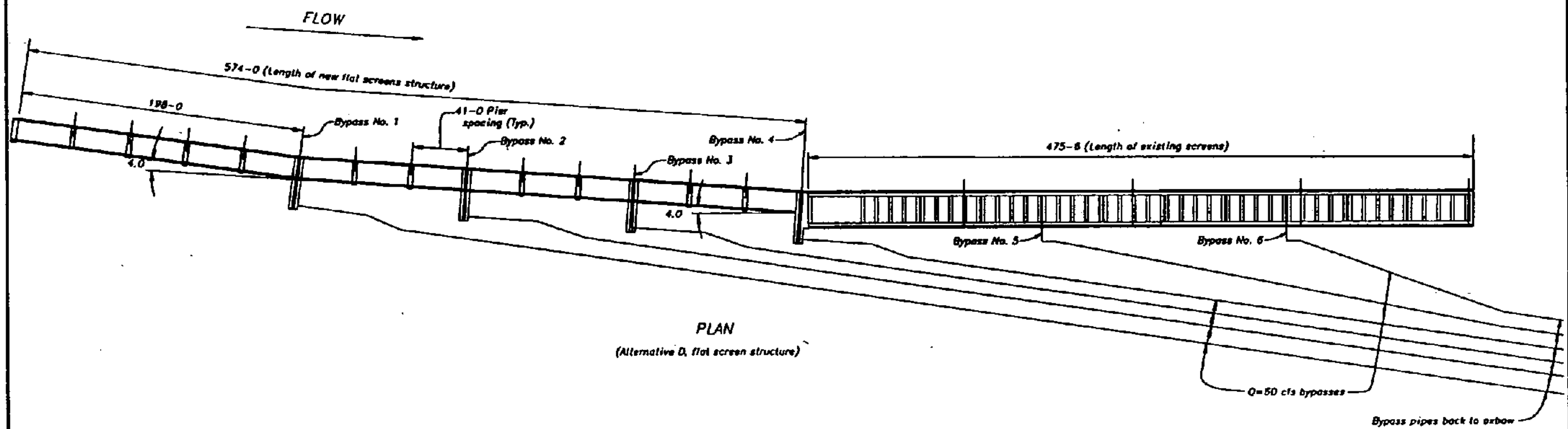


Figure 2.—Plan view of the flat plate screen with fish bypass locations tested in the model.

include the construction of a gradient facility (GF) in the main stem of the river, adjacent to Montgomery Island. The purpose of a GF is twofold. The structure would raise the river water surface upstream from the structure, thus increasing flow depth on the screen, and would increase hydraulic head available for operation of fish screen bypasses. Conditions with or without a gradient facility were accounted for in the model by changing the water surface elevation in front of the screen.

CONCLUSIONS

The Alternative D linear fish screen performed well in the model studies. Good uniformity of screen approach velocity and screen sweeping velocity were achieved for the range of riverflows between 7,000 cubic feet per second (ft^3/s) to 20,000 ft^3/s. Proper alignment of the opposite bank guide berm and the use of adjustable baffles mounted behind the screen were found to be important design parameters. A summary of important findings of the study are:

- Prior to baffling, approach velocity normal to the screen tends to be highest on the upstream most bay, just downstream from each bend in the screen and, under some operating conditions, near the downstream end of the screen. Screen baffling provided good control for correcting these problem areas.

- The velocity distribution in the vertical direction is fairly uniform. Reduced screen approach velocities do occur near the channel invert because of boundary influences.

- Reducing terminal bypass flow by up to 60 percent by operating multiple intermediate bypasses does not significantly affect the approach velocity distribution along the structure. The flow and location of internal fish bypasses along the screen do affect the approach channel width required to maintain nearly constant screen sweeping velocity. Visual observation of dye paths in the channel in front of the screens also shows operation of the bypasses increases the movement of flow toward the screens. The influence of the intermediate bypass flow is most prevalent at low river and pumping flows. Thus, progressively increasing the bypass flow allotted to internal bypasses increases the rate at which approach flow moves toward the screen.

- Full screen baffling was required to eliminate those areas along the screen where approach velocity exceeded 0.33 feet per second (ft/s). Full screen baffling also significantly reduced reverse flow at the downstream end of the screen during high riverflows.

- Moving screen baffles to the backside of the piers (~ 40 feet downstream from the screen) resulted in a loss of baffle effectiveness when compared to placing baffles near the screen.

FISH SCREEN PHYSICAL MODEL

Construction of the 1:16 scale physical model for Alternative D was completed on July 15, 1996. The model was constructed with six internal bypasses and an open terminal bypass. The model was designed and bypasses laid out such that testing could evaluate hydraulic conditions for screen designs with six, three, one, or no internal bypasses. A view of the model is shown in figure 3. Bypasses were positioned at the 4° breaks in the screen alignment and intermediate locations as needed to balance screen exposure time assuming six, three, or one bypass along the structure (figure 2). The oxbow channel in front of the screen structure was modeled at elevation 126.0, 1 foot lower than used in the previous 1:30 scale river model. The invert of the new screen structure was initially positioned at elevation 126.0, with the existing screen structure invert held at elevation 127.3. The total structure length was about 1,050 feet, with an open screen (structure length minus screen blocked by piers) length of 1,002 feet. The screen length and invert elevation were designed to be moveable, should model results or other factors require these parameters be modified. Removable screen baffles were designed to be positioned vertically behind the screen. Baffles were constructed as adjustable louver panels. Each panel was about 40 feet long and contained 20 vertical baffles 2 feet wide by 25 feet tall. All baffles within a panel were mechanically linked to provide a uniform baffle opening. The baffle panels in the model were designed to offer ease of adjustment for the model and may not reflect the final prototype design.

MODEL SIMILITUDE

The physical model of the fish screen structure must be geometrically and kinematically similar to the prototype to adequately predict prototype performance under specified operating conditions. Geometric similarity is achieved with the ratios of all prototype to model geometric parameters being equal. Kinematic similarity is achieved with the ratios of all prototype to model velocities being equal. Froude law similitude is employed to establish the kinematic relationship between model and prototype. This similitude is based on maintaining model and prototype Froude numbers which are equal. The required geometric and kinematic ratios for this 1:16 Froude scale model are as follows:

Geometric

$L_r = L_p/L_m = 16$

$A_r = (L_r)^2 = 256$

$V_r = (L_r)^3 = 4{,}096$

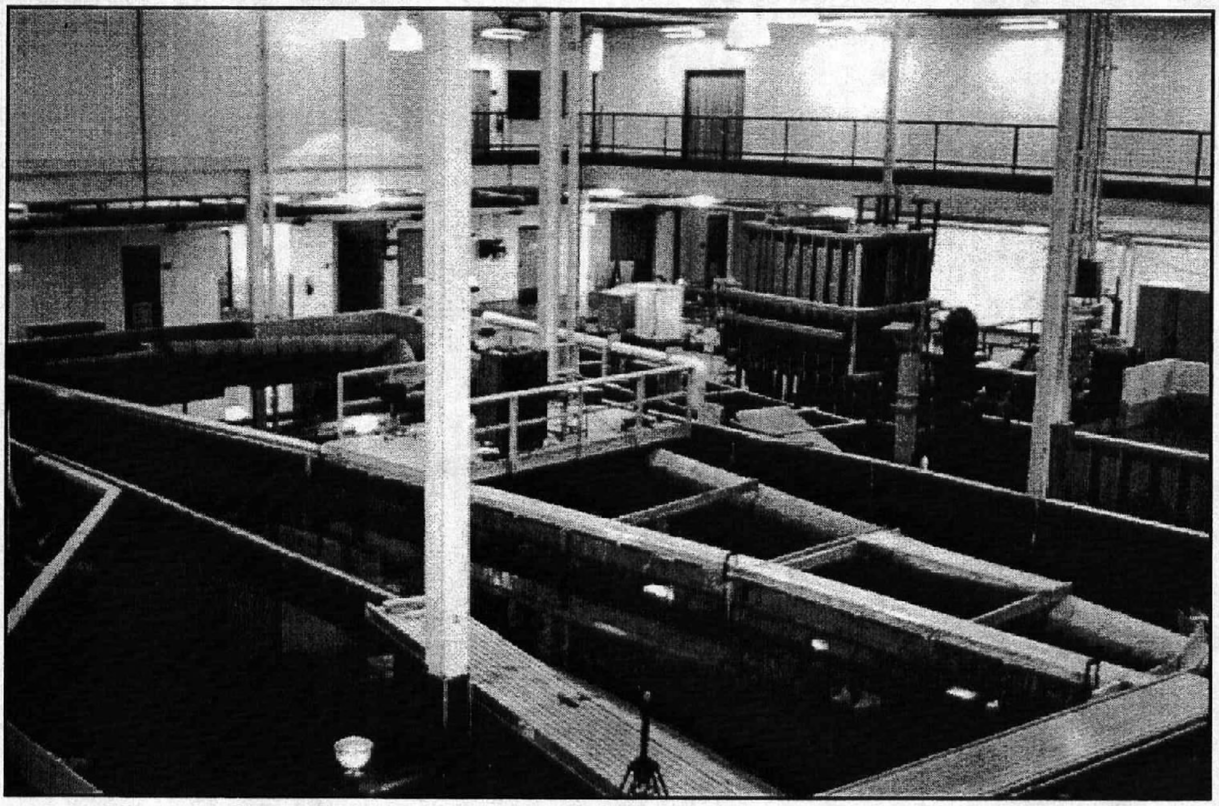


Figure 3.—Photograph of the 1:16 scale flat plate screen model.

Where:

L_p = Prototype characteristic length

L_m = Model characteristic length

L_r = Length ratio

A_r = Area ratio

V_r = Volume ratio

Kinematic

$t_r = (L_r)^{1/2} = 4.0$

$v_r = (L_r)^{1/2} = 4.0$

$a_r = 1$

$Q_r = (L_r)^{5/2} = 1,024$

Where:

t_r = Time ratio

v_r = Velocity ratio

a_r = Acceleration ratio

Q_r = Discharge ratio

MODEL INSTRUMENTATION

Water was supplied to the model from a 250,000-gallon sump by the laboratory pumping system. Discharge delivered to the model was measured using a permanent bank of laboratory venturi meters. The system is equipped with a flow controller to maintain the desired flow rate. Model tailwater elevations were maintained using stoplogs at the downstream end of the bypass channel. Water surface elevations were monitored throughout the model using point gauges set at specific locations of interest (i.e., intake channel, screen structure forebay, and bypass channel entrance). The pumping plant was simulated using a pump and manifold system in the model. Pumped discharge was measured using an ultrasonic flowmeter. The open channel bypass discharge was measured using a 30° v-notch weir. The discharge through the internal fish bypasses was measured by paddle wheel meters that were installed on each bypass pipe. Model velocities were measured using an acoustic doppler velocimeter (ADV) capable of acquiring continuous three-dimensional velocity measurements at a resolution of 0.001 ft/s with an accuracy of ±0.5 percent of full scale.

MODEL TESTS

Test Objectives

Model tests were conducted to obtain data for addressing several major issues confronting the concept design team. These issues were:

- Achieving uniformity of approach flow along the 1,000+ feet long screen
- Determining the optimum number and location of piped fish bypasses along the screen

- Defining hydraulic performance of the screen as a function of open channel bypass flow
- Determining the extent of screen baffling required

Each objective of the model study was investigated with the common goal of meeting State of California and Federal fish screen operating criteria. The governing fish screen criteria followed for the model study were (1) a screen approach velocity (velocity component measured normal to the screen face at a distance of 3 inches) of $\leq$ 0.33 ft/s and (2) a sweeping velocity (the velocity component parallel to the screen face) of $\geq$2 times the approach velocity. Although strict criteria would allow a sweeping velocity of 0.66 ft/s, the TAG set a minimum desirable sweeping velocity of 2.0 ft/s for the GCID screen. To achieve these objectives, model tests were conducted for a range of structure modifications, river conditions, and GCID diversion flows.

Data Collection

Flow visualization tests and point velocity measurements were used primarily to evaluate screen performance. Flow visualization was used to evaluate large scale flow patterns in the model. These tests employed both confetti and dye to establish surface and subsurface flow patterns, respectively. Tests were documented using video and photographs. Velocity measurements were acquired along the screen face at the centerline of each 40-foot-wide bay for the new screen structure and at the centerline of every fourth bay along the existing structure. At each location, a velocity profile with flow depth was obtained by traversing the ADV from near the channel invert to near the water surface. These data were then averaged to obtain values of average approach and sweeping velocity in front of the screen. All velocity measurements were made at about 3 inches (prototype) in front of the screen face.

Test Parameters

Hydraulic boundary conditions (water level and discharge) for the model were established using numerical flow simulations conducted by Ayers Associates. Ayers used a two-dimensional depth averaged finite element model to predict hydraulic conditions for a range of riverflows combined with GCID water diversions. Riverflow splits around Montgomery Island were also modeled with and without a proposed gradient control structure in the main river channel and check structure in the lower oxbow channel. Both structures were considered optional features of the fish screen project.

During the model study, three different scenarios of river gradient around the island were tested. Each scenario reflected a different assumption as to the size of gradient facility in the main branch of the river and check structure in the lower oxbow channel. Tables 1, 2, and 3 list the flow combinations numerically modeled and the major hydraulic data derived for each test.

Table 1.—Numerical model results of hydraulic conditions at GCID for 1991 river conditions (Ayers October 1995)

Sacramento River flow at North Island gauge (ft^3/s)	GCID intake channel diversion (ft^3/s)	GCID pumped diversion (ft^3/s)	Flow in GCID bypass channel (ft^3/s)	WSEL at North Island gauge (feet)	WSEL at GCID fish screens (feet)	WSEL at South Island gauge (feet)
5,000	1,670	1,000	670	135.4	135.1	134.2
7,000	2,914	2,500	414	135.8	134.9	134.4
10,000	3,615	3,000	615	136.8	135.9	135.2
20,000	4,793	3,000	1,793	139.9	139.4	138.2
40,000	7,404	3,000	4,415	144.5	144.2	142.8
60,000	9,255	1,000	8,275	148.5	148.3	146.7

Table 2.—Hydraulic conditions at GCID for a GMF with internal bypass system (Ayers August 1996)

Sacramento River flow at North Island gauge (ft^3/s)	GCID intake channel diversion (ft^3/s)	GCID pumped diversion (ft^3/s)	Flow in GCID bypass channel (ft^3/s)	WSEL at North Island gauge (feet)	WSEL at GCID fish screens (feet)	WSEL at South Island gauge (feet)
5,000	1,570	1,000	570	137.5	137.4	134.2
7,000	3,000	2,500	50	137.5	137.1	134.4
10,000	3,615	3,000	840	137.9	138.6	135.2
20,000	4,900	3,000	1,900	139.9	141.3	138.2
40,000	7,530	3,000	4,453	144.5	145.0	142.8
60,000	9,130	1,000	8,130	148.5	149.1	146.7

Table 3.—Hydraulic conditions at GCID for a GF2 with internal bypass system (Ayers December 1996)

Sacramento River flow at North Island gauge (ft^3/s)	GCID intake channel diversion (ft^3/s)	GCID pumped diversion (ft^3/s)	GCID internal bypass discharge (ft^3/s)	Flow in GCID bypass channel (ft^3/s)	WSEL at North Island gauge (feet)	WSEL at GCID fish screens (feet)	WSEL at South Island gauge (feet)
5,000	1,570	1,000	150	420	137.5	137.4	134.2
7,000	3,500	3,000	150	350	137.5	137.0	134.2
8,000	3,590	3,000	150	440	137.9	137.4	134.5
10,000	3,775	3,000	150	625	138.6	138.2	135.2
20,000	4,750	3,000	150	1,600	141.1	140.9	137.9

Model Operation

Water level and discharge conditions for each test were established and allowed to reach steady state prior to data collection. The procedure required discharge to the upper oxbow channel be set, then GCID pumped flow, piped bypass flow, and water surface elevation be adjusted to match conditions predicted by the numerical model. Water surface elevation in the upper oxbow was measured using a point gauge located on the upstream end of the screen structure. Pipe bypass flow was controlled by adjusting individual valves on each bypass pipe.

MODEL TEST RESULTS

Screen Alignment and Fish Bypasses

In tests 1 through 14 (listed in table 4), general flow conditions resulting from screen orientation and the effect on screen performance of operating internal bypasses were investigated. These tests were conducted assuming a GMF in the main river, a check structure downstream from the screens, and no baffles behind the screen, as given in table 2. Tests were conducted with zero, one, three, and six internal bypasses operating. Through discussions with the National Marine Fisheries Service, it was agreed that total bypass flow would be held constant and terminal bypass flow would be reduced by that drawn off for internal bypasses. For example, a terminal bypass flow of 500 ft^3/s with no internal bypasses was reduced to 140 ft^3/s with six bypasses operating at 60 ft^3/s each.

Approach and sweeping velocity profiles measured along the screen are given in tests 1- 14. In general, uniformity of approach velocity measured normal to the screen was good. Some consistently high areas of approach velocity did occur at the screen's upstream end and just downstream from each 4° break in screen alignment.

The test data show operating up to six internal fish bypasses (evenly spaced along the screen) in conjunction with reduced terminal bypass flow does not significantly affect the through-screen velocity distribution. However, reducing the terminal bypass flow causes a progressive decrease in the sweeping velocity component moving down the screen (see tests 6, 7, and 8). The screen forebay channel geometry tested was designed assuming only an open channel terminal bypass, as given in test 8. As shown by tests 6 and 7, diverting bypass water from the open channel bypass to the internal bypasses requires the forebay channel geometry to be narrowed if nearly constant sweeping velocity along the full length of screen is to be achieved. This also demonstrates the point that, given a fixed total bypass flow, the larger the bypass flow used for internal bypasses the greater the percentage of flow that comes in contact with the screen structure. For example, compare tests 1 and 4 in table 4 for 5,000 ft^3/s river flow. In test 1, where no internal bypasses are operated, 36 percent of the inlet channel flow passes by the structure to the lower oxbow. For the same river conditions, operating six

Table 4.—Flat plate screen model test runs

Test No.	River Conditions Simulated (1991 or GMF)	Internal Pipe Bypasses	River Flow (cfs)	GCID Pumped Discharge (cfs)	Upper Oxbow Channel Flow (cfs)	Internal Pipe Bypass Flow (cfs)	Open Channel Bypass Flow (cfs)	Water Surface at Screens (ft)	Screen Bays Baffled (Bays numbered DS to US) (Bay Number)
			Summary of 1:16 Scale GCID Fish Screen Model Tests						
{Model test conditions reflect Ayers Numerical data given in July 19, 1996 memo}									
1	GMF & Check	All closed	5,000	1,000	1,570	0	570	137.4	None
2	GMF & Check	#4 Open	5,000	1,000	1,570	60	510	137.4	None
3	GMF & Check	#1,4 & 6 Open	5,000	1,000	1,570	180	390	137.4	None
4	GMF & Check	All Open	5,000	1,000	1,570	360	210	137.4	None
5	GMF & Check	All Open	7,000	2,500	3,500	360	140	137.1	None
6	GMF & Check	All Open	10,000	3,000	3,840	360	480	138.6	None
7	GMF & Check	#1,4 & 6 Open	10,000	3,000	3,840	180	660	138.6	None
8	GMF & Check	All closed	10,000	3,000	3,840	0	840	138.6	None
9	GMF & Check	#1,4 & 6 Open	20,000	3,000	4,900	180	1,720	141.3	None
10	GMF & Check	All closed	20,000	3,000	4,900	0	1,900	141.3	None
11	GMF & Check	#1,4 & 6 Open	40000	3,000	7,530	180	4,350	145.0	None
12	GMF & Check	All closed	40000	3,000	7,530	0	4,530	145.0	None
13	GMF & Check	All closed	60000	1,000	9,130	0	8,130	149.1	None
14	GMF & Check	#1,4 & 6 Open	60000	1,000	9,130	180	7,950	149.1	None
15	GMF & Check	All closed	7,000	2,500	3,500	0	500	137.1	41,42,50,51 & 55
16	GMF & Check	All closed	10,000	3,000	3,840	0	840	138.6	41,42,50,51 & 55
17	GMF & Check	All closed	20,000	3,000	4,900	0	1,900	141.3	41,42,50,51 & 55
18	GMF & Check	All closed	40,000	3,000	7,530	0	4,530	145.0	41,42,50,51 & 55
19	GMF & Check	All closed	60,000	1,000	9,130	0	8,130	149.1	41,42,50,51 & 55
20	1991	All closed	5000	1,000	1,500	0	500	135.2	None
21	1991	All closed	7000	2,500	3,000	0	500	135.5	None
22	1991	All closed	7,000	2,500	3,000	0	500	134.9	1,2,3,38,41,42,50,51 & 55
23	1991	All closed	10,000	3,000	3,425	0	425	135.9	1,2,3,38,41,42,50,51 & 55
24	1991	All closed	20,000	3,000	3,000	0	875	139.5	1,2,3,38,41,42,50,51 & 55
25	1991	All closed	40,000	3,000	7,100	0	4100	144.1	1,2,3,38,41,42,50,51 & 55
{Test conditions reflect design change to 3 Internal fish bypasses, screen angle change to 2.9 degrees and hydraulic conditions as presented by Ayers in January, 1997}									
26	GF2 & Check	All 3 Open	7000	3000	3500	150	350	137.0	All
27	GF2 & Check	All 3 Open	10000	3000	3775	150	625	138.2	All
28	GF2 & Check	All 3 Open	20000	3000	4750	150	1600	141.1	All
{Training wall is moved into the channel along the lower 1/2 thus narrowing the channel.}									
29	GF2 & Check	All 3 Open	5000	1000	1570	150	420	137.4	All
30	GF2 & Check	All 3 Open	7000	3000	3500	150	350	137.0	All
31	GF2 & Check	All 3 Open	10000	3000	3775	150	625	138.2	All
32	GF2 & Check	All 3 Open	20000	3000	4750	150	1600	141.1	All
{Baffles placed behind the screen structure.}									
33	GF2 & Check	All 3 Open	7000	3000	3500	150	350	137.0	All
34	GF2 & Check	All 3 Open	10000	3000	3775	150	625	138.2	All
35	GF2 & Check	All 3 Open	20000	3000	4750	150	1600	141.1	All
{Near bypass screen velocity tests. Each test covers one bypass entrance.}									
36	GF2 & Check	All 3 Open	10000	3000	3775	150	625	138.2	All
37	GF2 & Check	All 3 Open	10000	3000	3775	150	625	138.2	All
38	GF2 & Check	All 3 Open	10000	3000	3775	150	625	138.2	All

internal bypasses reduces the flow passing the structure to 13 percent of inlet channel flow. Thus, increasing the number of bypasses operating can significantly change how flow approaches the screen and increases the probability of fish being drawn toward the screen, especially for low riverflows.

Screen Baffling Tests

In tests 15 through 25, the effect of screen baffling was investigated. The position of the baffles is shown in figure 4. Initially, limited baffling was installed behind the screen in bays where the approach velocity was found to be consistently higher than the average approach velocity along the screen. Tests 15 through 19 were conducted assuming a GMF, check structure (table 3), and no internal pipe bypasses. Baffles were placed behind the screen in bays 41, 42, 50, 51, and 55 (each bay being about 40 feet wide). Baffle opening was adjusted by placing the ADV in front of each baffled bay and reading flow velocity at mid-depth while reducing the baffle opening. Limited screen baffling showed good results for the screen bays that were baffled. A comparison of tests 10 and 17 shows approach velocity peaks noted just downstream from the 4° bends for unbaffled conditions were removed by baffling.

A series of tests were also conducted for the option with no GMF, check structure, or internal pipe bypasses and 1991 river conditions (table 1). Tests 20 and 21 present baseline data for an unbaffled screen. These tests show similar characteristics in the velocity field as identified for the GMF and check structure option. Above average values of screen approach velocity occur downstream from each 4° bend and near the screen's upstream end. Lower than average approach velocity occurs near the downstream end of the screen. Screen sweeping velocity increases from downstream to upstream along the screen. To dampen high approach velocity areas, baffles were installed behind the screen in bays 38, 39, 40, and 41 in the existing structure and bays 42, 50, 51, and 55 of the new screen. In addition, baffles were placed in bays 1, 2, and 3 to determine the impact of baffling on reverse flow that occurs through the downstream end of the screen during high river conditions.

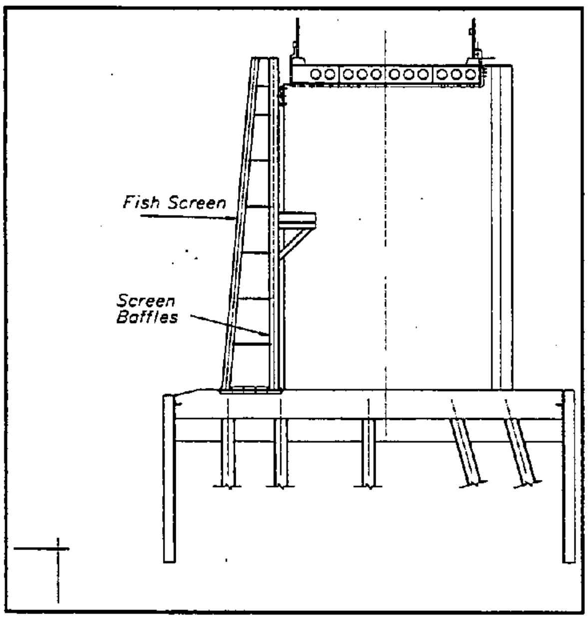


Figure 4.—Cross sectional view of fish screen showing baffle location.

In each test, baffles were an effective method of adjusting screen approach velocity. However, adjusting the flow through the baffled bays often shifted the problem to another area of the screen that was unbaffled. This effect is evident in tests 22 and 23. Baffling bays 1, 2, and 3 reduced return flow through the baffled bays but did not provide noticeable improvement upstream from the baffled area (test 25).

Design With Three Fish Bypasses

The above results were presented to the TAG for comment. The TAG decided to focus on the design of a fish screen structure with three internal fish bypasses and full screen baffling. The TAG expressed the desire to minimize screen exposure time (the time it takes flow to pass between fish bypasses) while not exceeding a maximum exposure time of about 2 ½ minutes (assuming river flows ≥ 7,000 ft^3/s). This required the three internal bypasses be positioned at nearly equal distances along the screen. The position and angle of the bend in the screen farthest upstream was also changed to maintain the design of adjacent bends and bypasses. To accomplish this without altering the end positions of the screen, the bend in the screen alignment farthest upstream was moved to the midpoint of the new screen (~ 288 feet from the upstream end), and the angle was reduced from 4° to 2.9° (figure 5). The third fish bypass was positioned at the midpoint of the old screen. This positioning of bypasses breaks the screen into four segments of 288, 288, 237, and 237 feet from upstream to downstream, respectively. Assuming an average sweeping velocity of 2 ft/s along the screen yields an exposure time for the 288-foot length between bypasses of 2.4 minutes.

Tests of Final Screen Geometry

Tests 26 trough 28 give test results for the modified screen layout with full baffling of all bays, three internal fish bypasses, a gradient structure (GF2), and a check structure in the lower oxbow channel. A revision in the design of the gradient structure and check resulted in new flow conditions for the model. The flow conditions used in the remainder of the tests are given in table 3. Baffles were set in the model for a river flow of 7,000 ft^3/s. Starting at the upstream end of the screen and moving downstream, each bay of baffles was adjusted to achieve an approach velocity of 0.3 ft/s. The opening of each baffle was set by measuring velocity at the center of each screen bay at midflow depth. Two passes down the length of the screen were found necessary to attain good uniformity of approach velocity. This procedure resulted in an average baffle opening of 15 percent in the model. Baffle openings ranged between 12 and 18 percent. Test 26 shows approach and sweeping velocity magnitudes for 7,000 ft^3/s river flow. Good uniformity of approach velocity was achieved along the screen length. In addition, full baffling of the screen resulted in much reduced reverse flow out the downstream end of the screen at high riverflows. A sharp decrease in reverse flow is seen for a 20,000 ft^3/s river condition in test 28 compared to test 10 (an unbaffled case) or test 17 (partial upstream baffling).

A drop off in sweeping velocity consistent with previous testing for the gradient facility and check structure option was again apparent downstream from bypass 3 (farthest upstream bypass). To achieve better uniformity of sweeping velocity along the screen, the width of the approach channel downstream of bypass 3 was gradually narrowed by adding fill to the opposite bank training wall. The final alignment of the training wall is shown in figure 5. Tests 29 through 32 give screen performance with the narrowed channel. A comparison of tests 26 and 30 show sweeping velocity improvement achieved by narrowing the channel for the gradient facility and check structure option.

Tests of Baffle Location

Maintenance access is needed to the back side of the screen and the front side of the baffles. Therefore, it was important to determine if the baffles could be moved downstream from the screen without losing effectiveness. A design with baffles mounted on the downstream end of the piers was evaluated in the model. Baffles for the new screen were repositioned behind the piers in the model. The front of each pier was also modified to isolate flow in each bay. Flow passing through the screen between adjacent piers remained between the same piers until leaving the structure. Baffles along the old screen structure were not changed in the model due to the substantial model modifications that were required for the old pier geometry. Baffle openings were again adjusted to achieve the best uniformity of approach velocity possible. Tests 33 through 35 give approach and sweeping velocity results for the repositioned baffles. Substantial loss of adjustment was noted in the tests. The uniformity of approach velocity obtained in the tests required baffle percent openings be varied from about 5 percent open to full open along the screen.

Near-Bypass Velocity Tests

Tests to determine the velocity field near each bypass were conducted. Mid-depth velocities were measured 3 inches in front of the screen every 2.6 feet along the screen for a distance of 24 feet either side of the bypass centerline. The bypass entrance was modeled with a 2-foot-wide throat and a bellmouth entrance (figure 6). Tests 36 to 38 give screen approach and sweeping velocities for each bypass. Across the width of the bellmouth entrance, the flow turns sharply into the bypass entrance. In front of the bellmouth entrance, the flow's sweeping velocity component turns toward the bypass entrance, thus producing a sharply higher screen approach velocity and a corresponding decrease in sweeping velocity. Upstream from the bypass entrance for a distance of about 20 feet, screen approach velocity gradually decreases toward the bypass. Downstream, elevated levels of approach velocity occur for a similar distance. The elevated screen approach velocity downstream from the bypass entrance is caused by the gradual return of flow alignment to the screen.

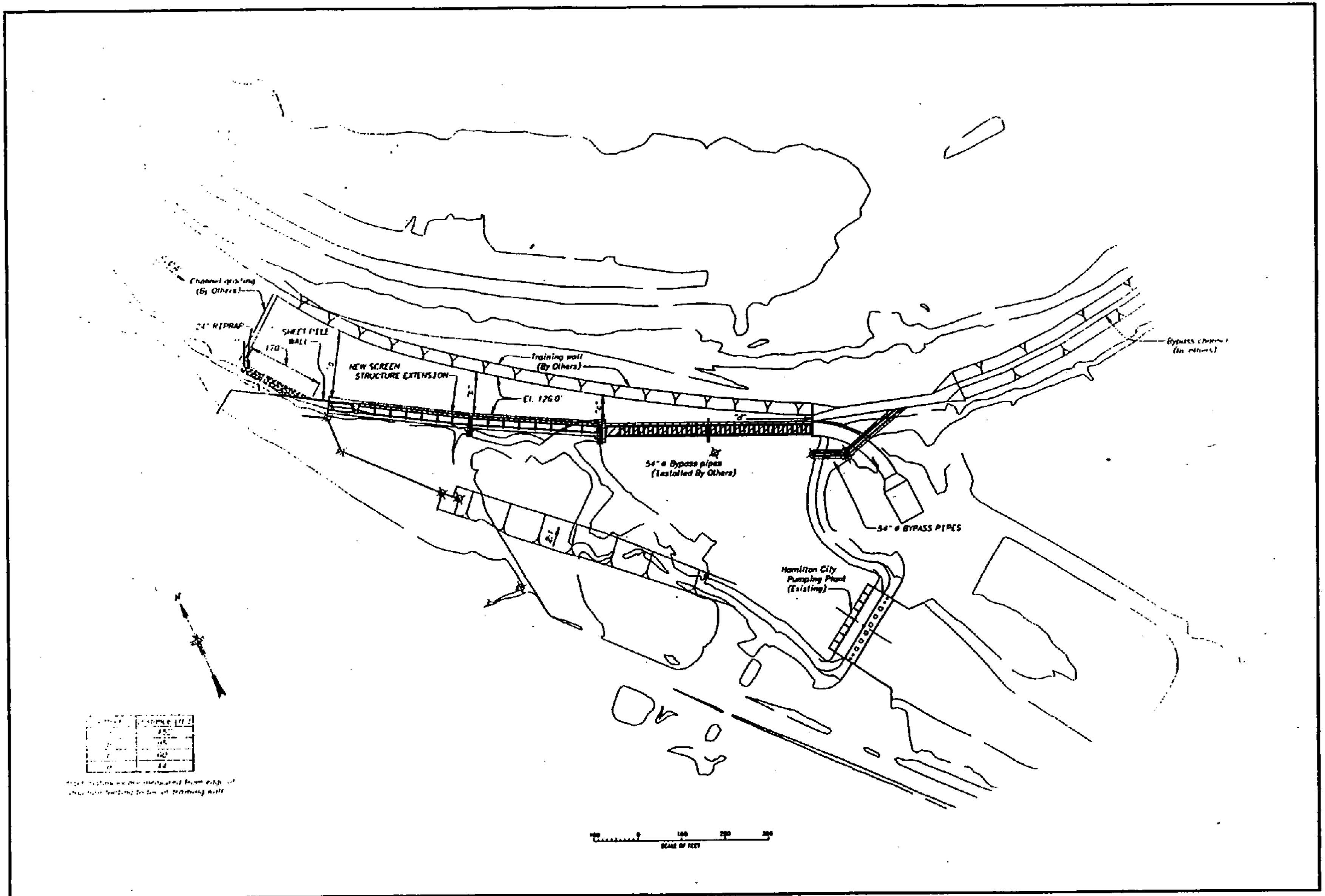


Figure 5.—Plan view of fish screen showing the position of the opposite bank training wall.

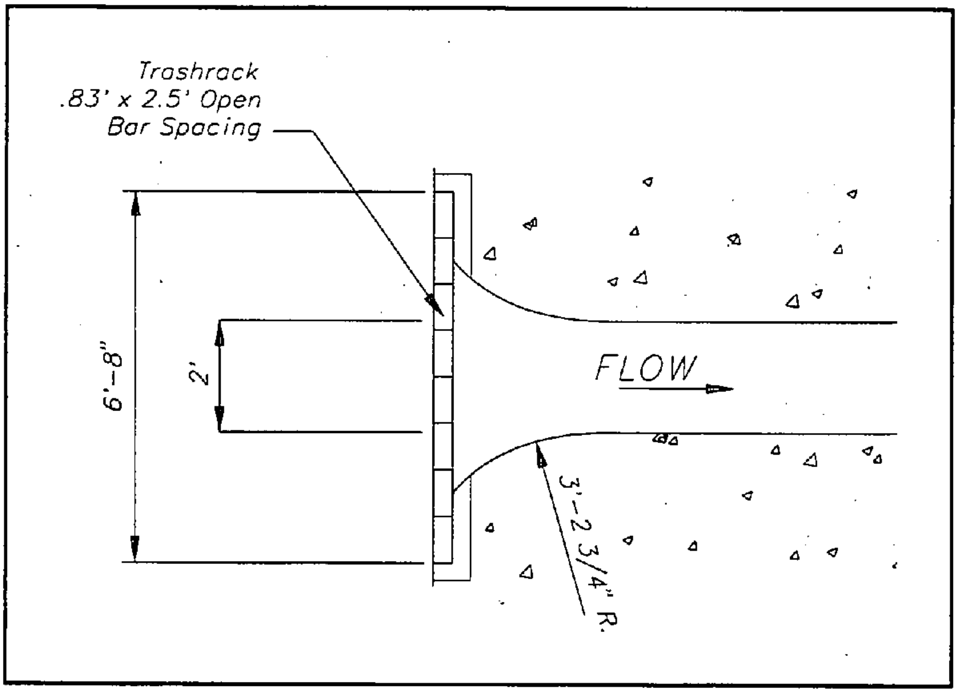
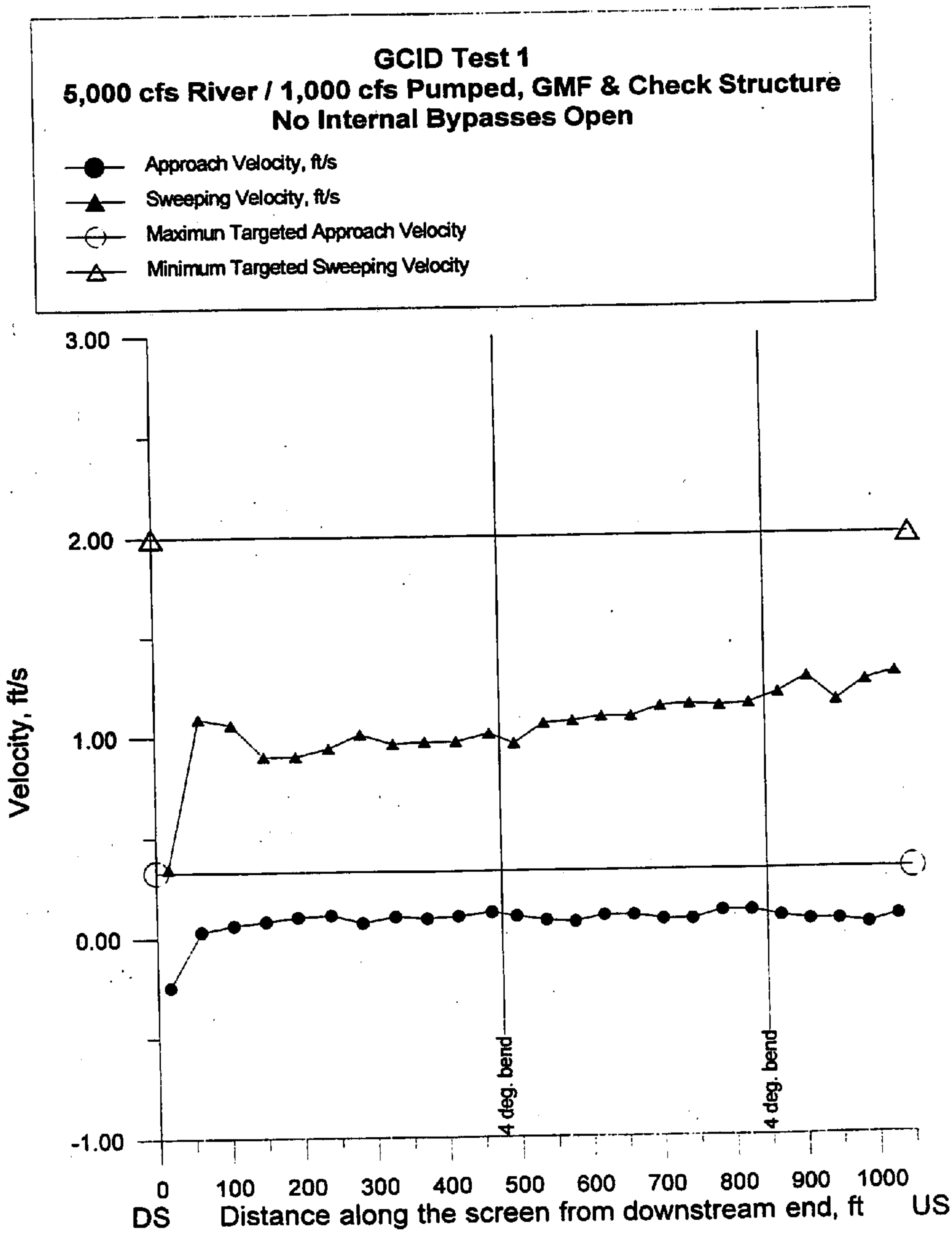
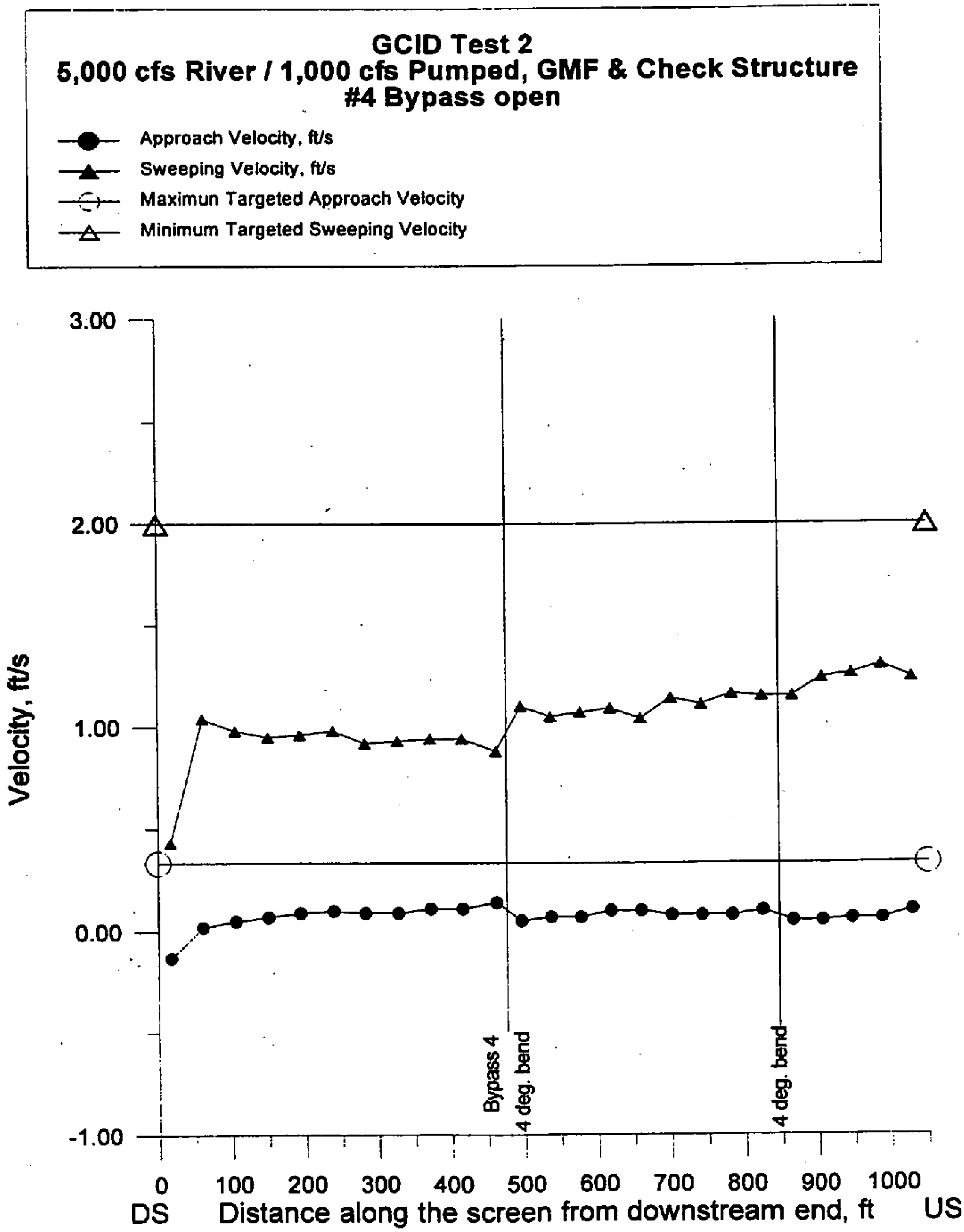


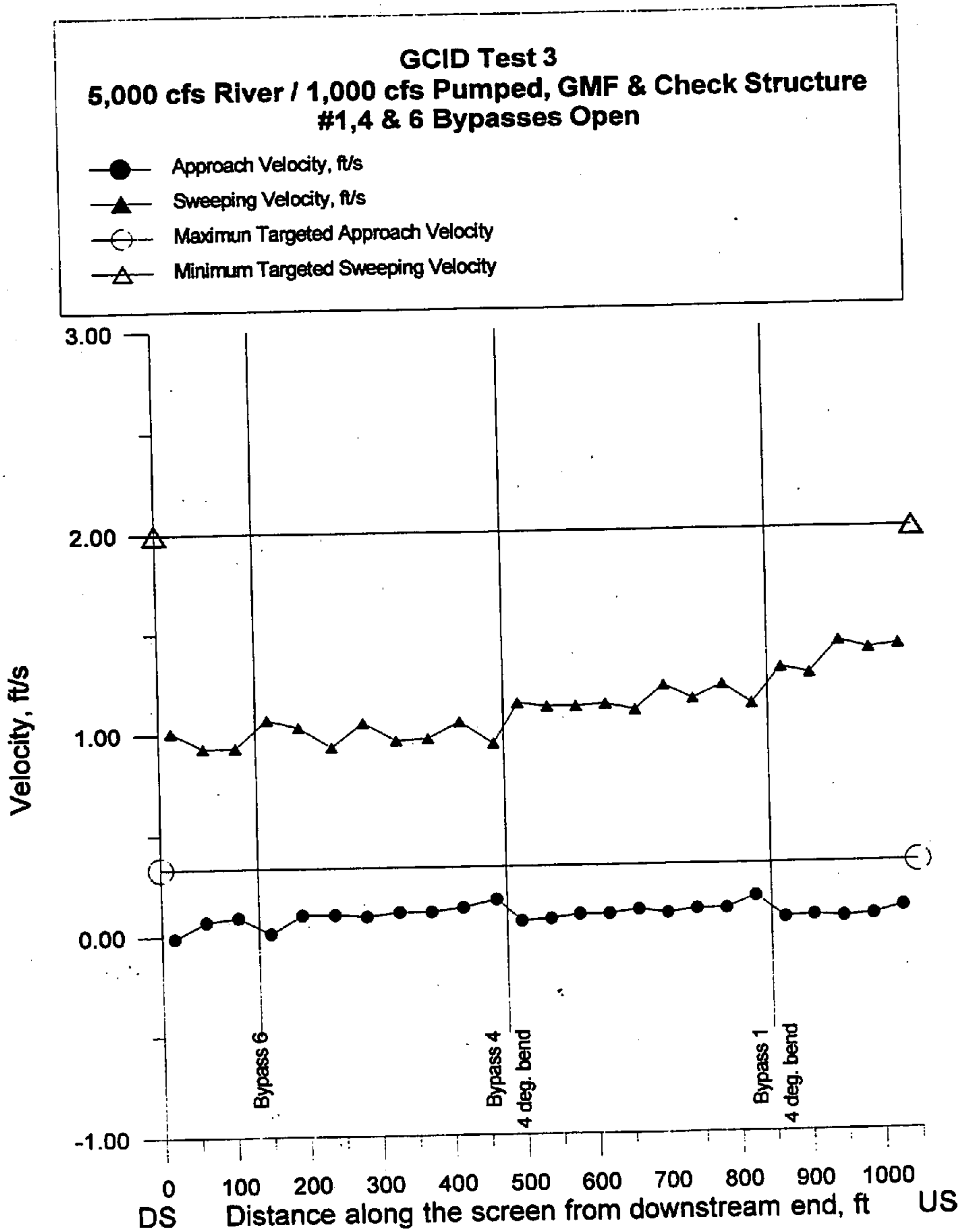
Figure 6.—Plan view of fish screen bypass entrance showing bellmouth and course trashrack.



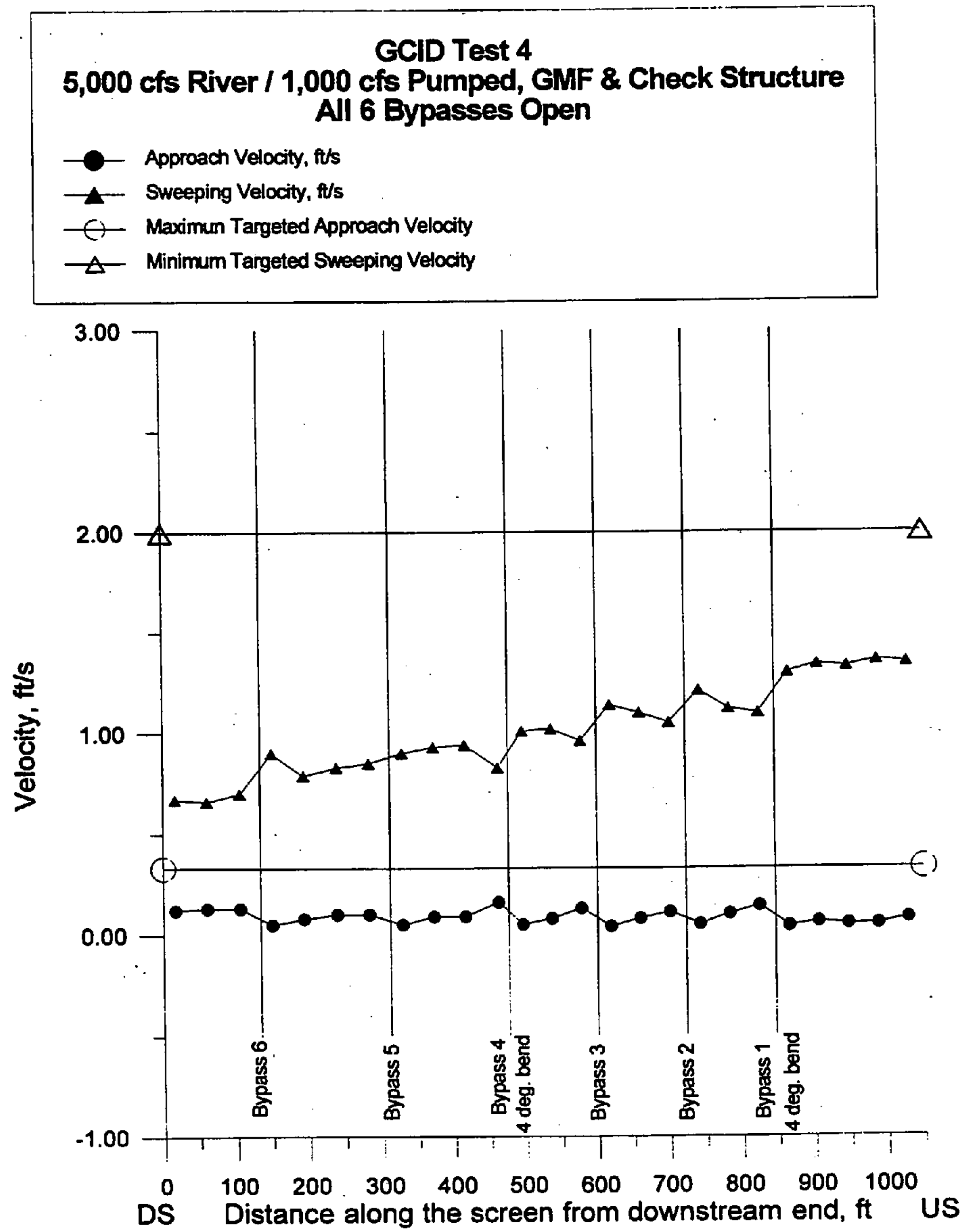
GCID Test 1
5,000 cfs River / 1,000 cfs Pumped, GMF & Check Structure
No Internal Bypasses Open
Approach Velocity, ft/s
Sweeping Velocity, ft/s
Maximun Targeted Approach Velocity
Minimum Targeted Sweeping Velocity
Velocity, ft/s
3.00
2.00
1.00
0.00
-1.00
4 deg. bend
4 deg. bend
0
100
200
300
400
500
600
700
800
900
1000
DS
Distance along the screen from downstream end, ft
US

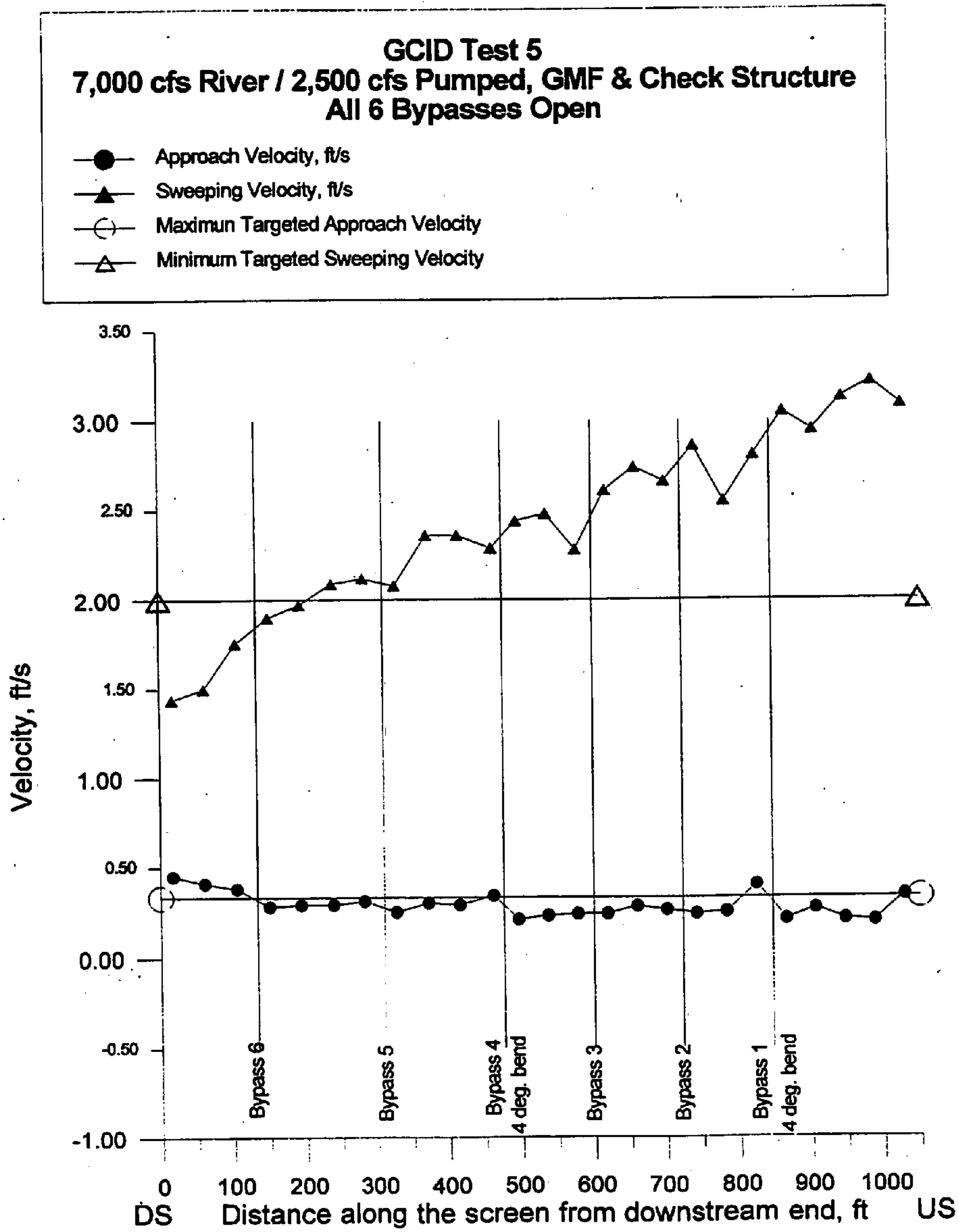


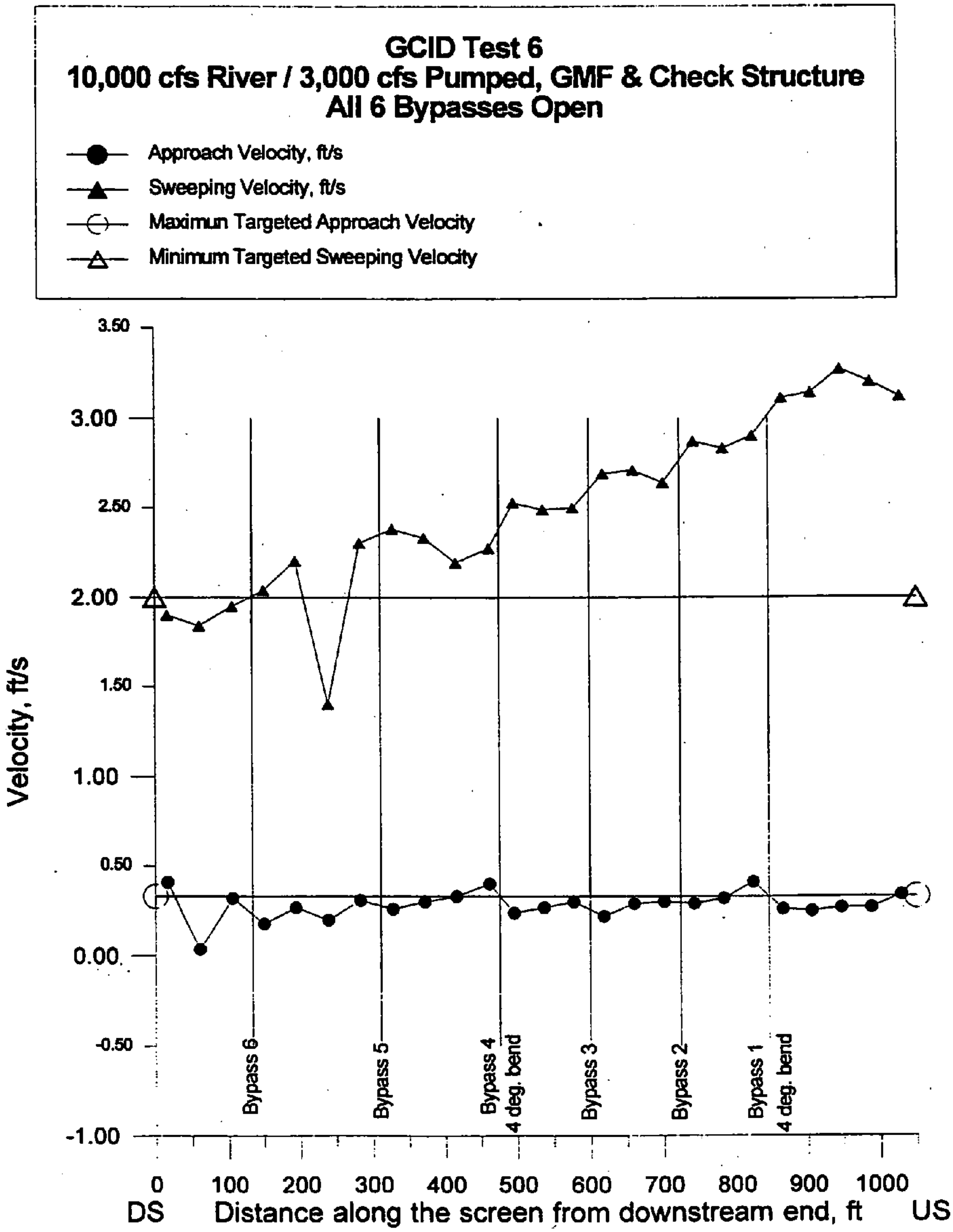
GCID Test 2
5,000 cfs River / 1,000 cfs Pumped, GMF & Check Structure #4 Bypass open
Approach Velocity, ft/s
Sweeping Velocity, ft/s
Maximun Targeted Approach Velocity
Minimum Targeted Sweeping Velocity
Velocity, ft/s
3.00
2.00
1.00
0.00
-1.00
Bypass 4
4 deg. bend
4 deg. bend
0
100
200
300
400
500
600
700
800
900
1000
DS
Distance along the screen from downstream end, ft
US

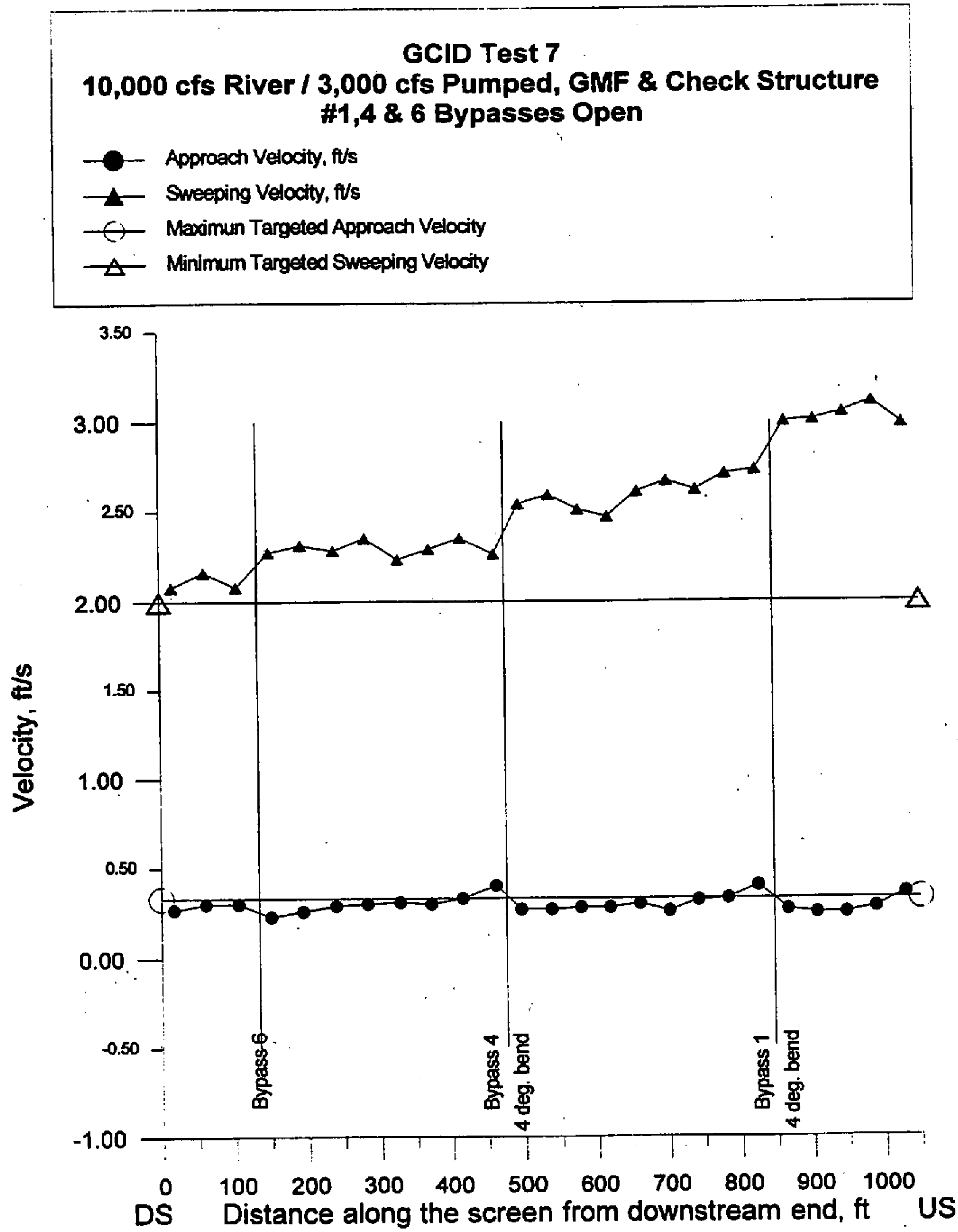


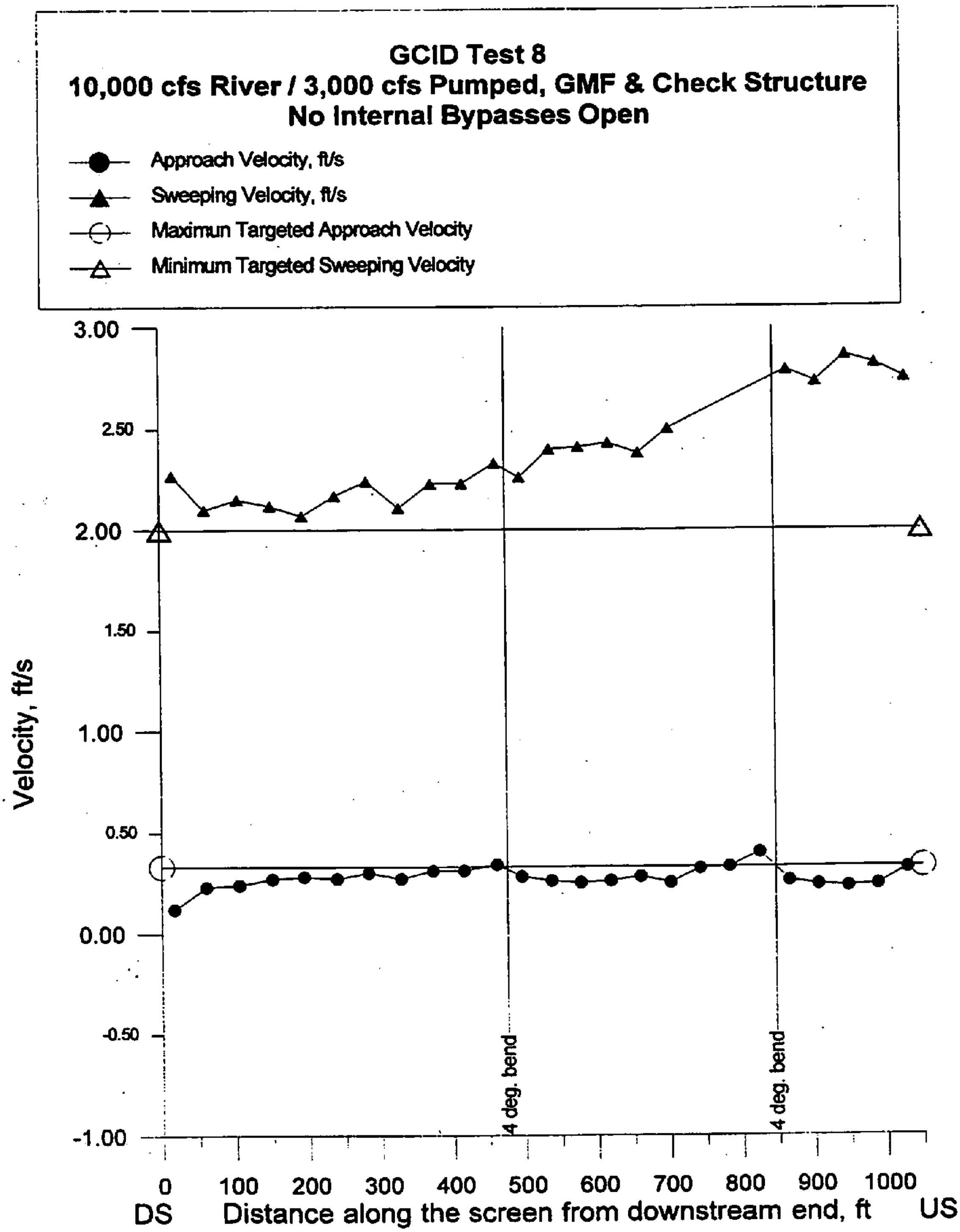
GCID Test 3
5,000 cfs River / 1,000 cfs Pumped, GMF & Check Structure
#1,4 & 6 Bypasses Open
Approach Velocity, ft/s
Sweeping Velocity, ft/s
Maximun Targeted Approach Velocity
Minimum Targeted Sweeping Velocity
3.00
2.00
1.00
0.00
-1.00
Velocity, ft/s
Bypass 6
Bypass 4
4 deg. bend
Bypass 1
4 deg. bend
0
100
200
300
400
500
600
700
800
900
1000
DS
Distance along the screen from downstream end, ft
US

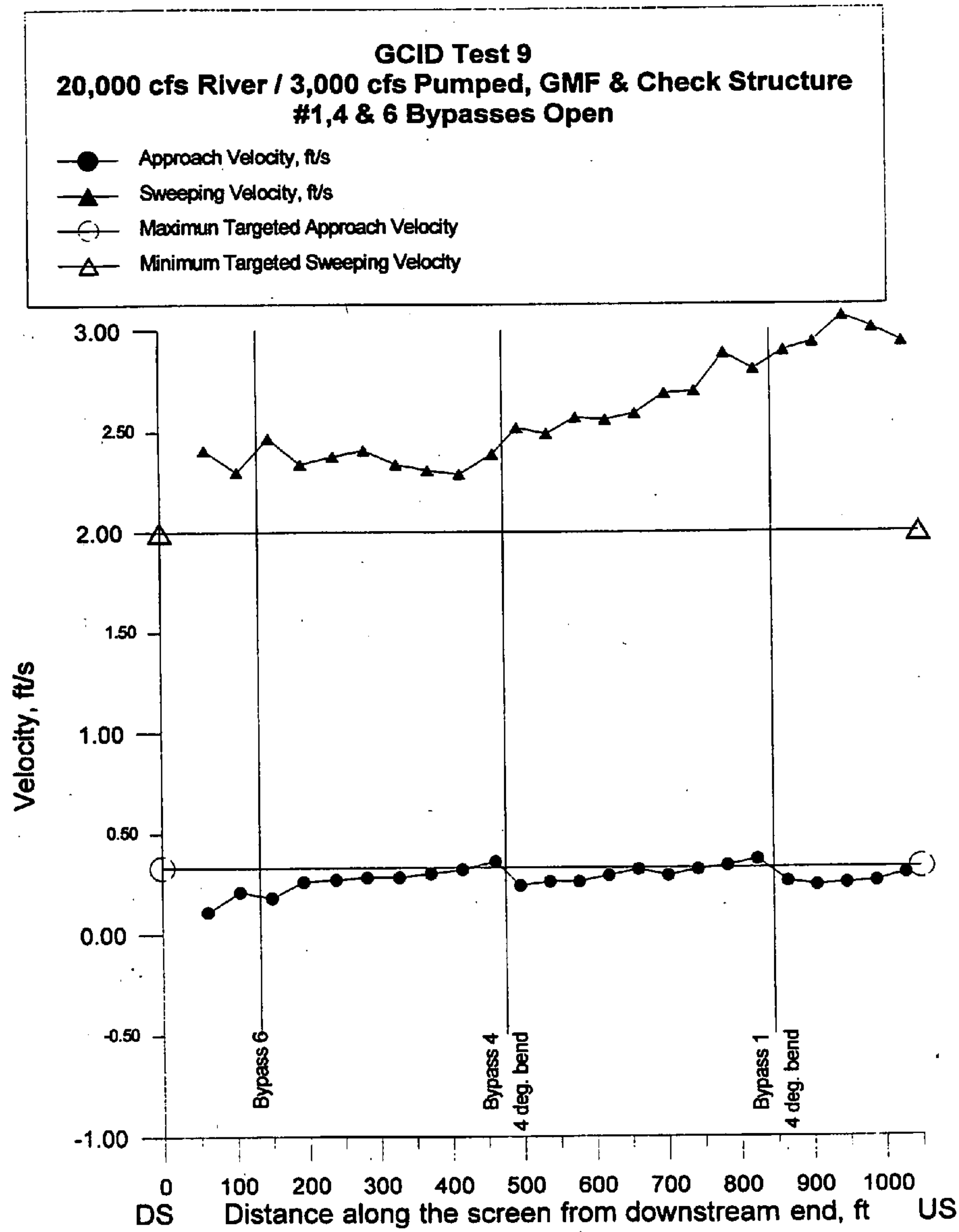

GCID Test 4
5,000 cfs River / 1,000 cfs Pumped, GMF & Check Structure
All 6 Bypasses Open
Approach Velocity, ft/s
Sweeping Velocity, ft/s
Maximun Targeted Approach Velocity
Minimum Targeted Sweeping Velocity
Velocity, ft/s
3.00
2.00
1.00
0.00
-1.00
Bypass 6
Bypass 5
Bypass 4
4 deg. bend
Bypass 3
Bypass 2
Bypass 1
4 deg. bend
0
100
200
300
400
500
600
700
800
900
1000
DS
Distance along the screen from downstream end, ft
US

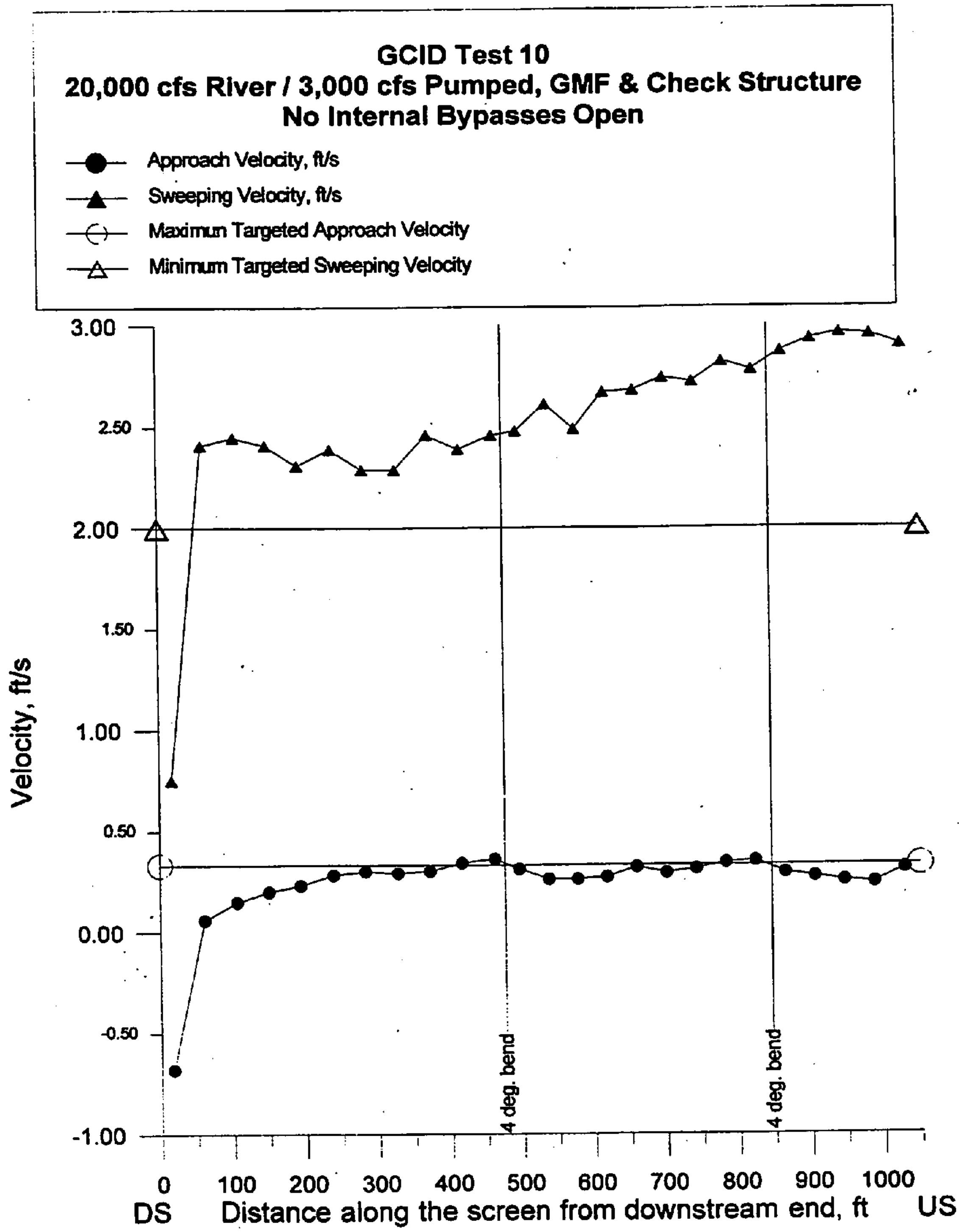

GCID Test 5
7,000 cfs River / 2,500 cfs Pumped, GMF & Check Structure
All 6 Bypasses Open
Approach Velocity, ft/s
Sweeping Velocity, ft/s
Maximun Targeted Approach Velocity
Minimum Targeted Sweeping Velocity
Velocity, ft/s
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
-0.50
-1.00
Bypass 6
Bypass 5
Bypass 4
4 deg. bend
Bypass 3
Bypass 2
Bypass 1
4 deg. bend
0
100
200
300
400
500
600
700
800
900
1000
DS
Distance along the screen from downstream end, ft
US


GCID Test 6
10,000 cfs River / 3,000 cfs Pumped, GMF & Check Structure
All 6 Bypasses Open
Approach Velocity, ft/s
Sweeping Velocity, ft/s
Maximun Targeted Approach Velocity
Minimum Targeted Sweeping Velocity
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
-0.50
-1.00
Velocity, ft/s
Bypass 6
Bypass 5
Bypass 4
4 deg. bend
Bypass 3
Bypass 2
Bypass 1
4 deg. bend
0
100
200
300
400
500
600
700
800
900
1000
DS
Distance along the screen from downstream end, ft
US

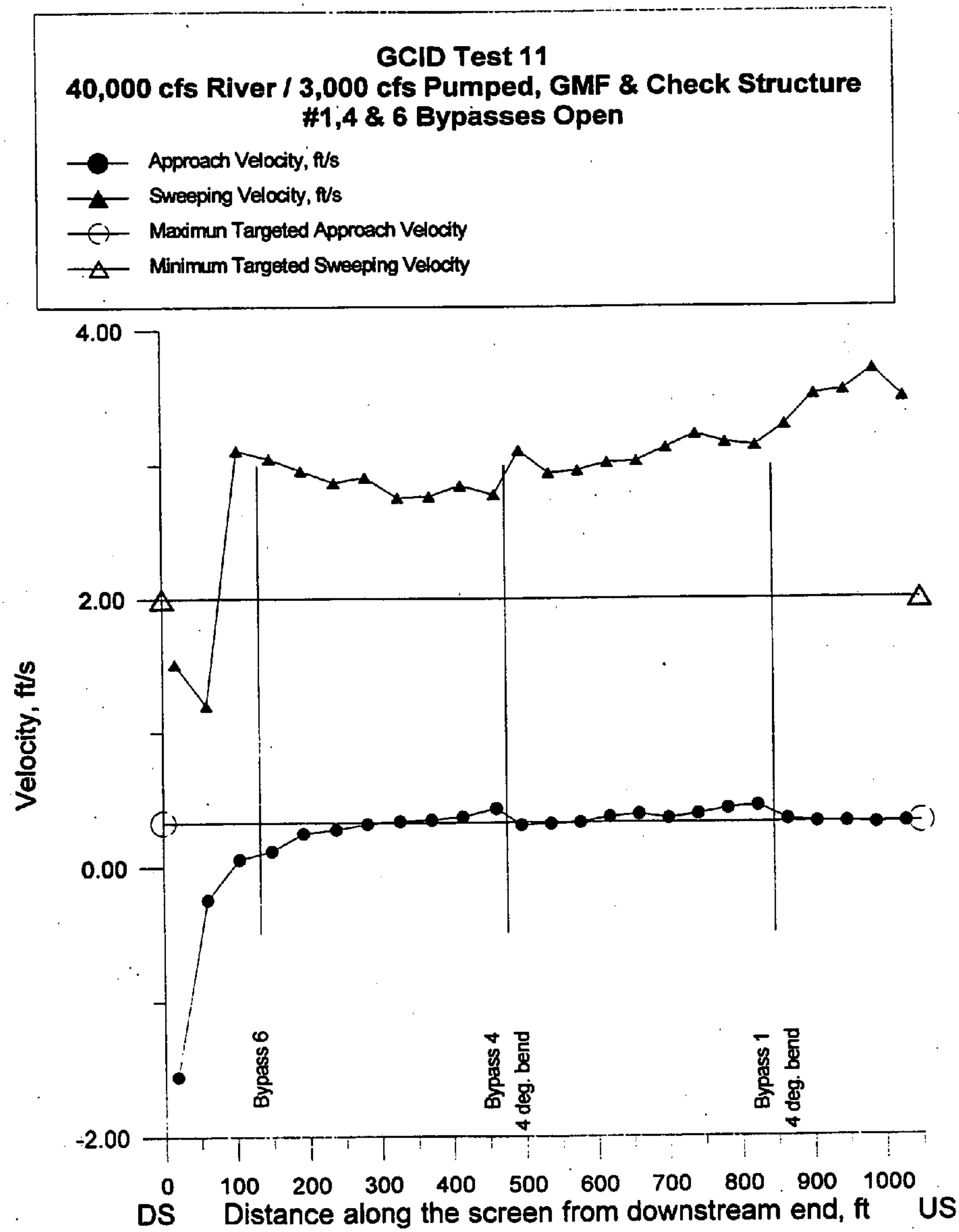

GCID Test 7
10,000 cfs River / 3,000 cfs Pumped, GMF & Check Structure
#1,4 & 6 Bypasses Open
Approach Velocity, ft/s
Sweeping Velocity, ft/s
Maximun Targeted Approach Velocity
Minimum Targeted Sweeping Velocity
Velocity, ft/s
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
-0.50
-1.00
Bypass 6
Bypass 4
4 deg. bend
Bypass 1
4 deg. bend
0
100
200
300
400
500
600
700
800
900
1000
DS
Distance along the screen from downstream end, ft
US


GCID Test 8
10,000 cfs River / 3,000 cfs Pumped, GMF & Check Structure
No Internal Bypasses Open
Approach Velocity, ft/s
Sweeping Velocity, ft/s
Maximun Targeted Approach Velocity
Minimum Targeted Sweeping Velocity
Velocity, ft/s
3.00
2.50
2.00
1.50
1.00
0.50
0.00
-0.50
-1.00
4 deg. bend
4 deg. bend
0
100
200
300
400
500
600
700
800
900
1000
DS
Distance along the screen from downstream end, ft
US

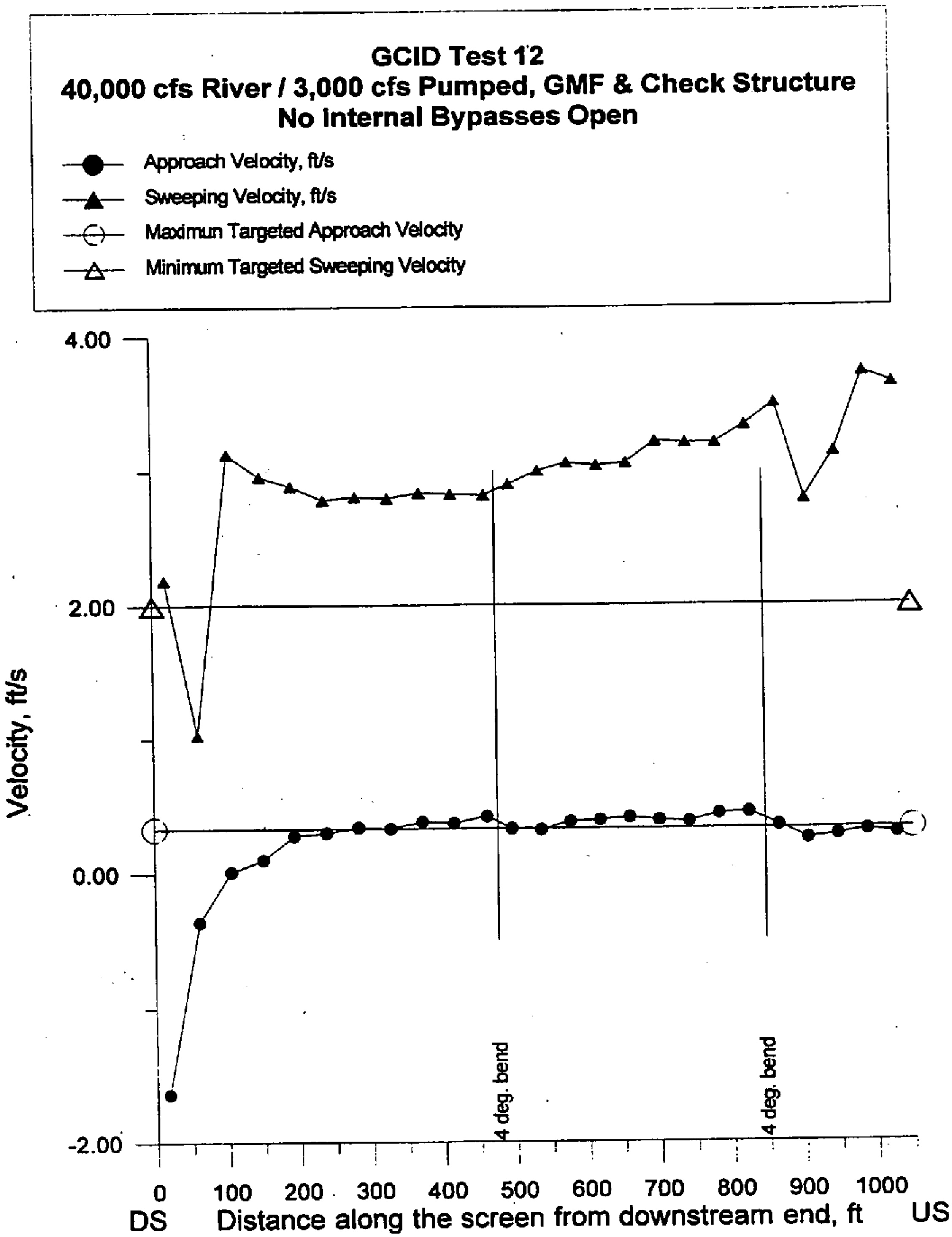

GCID Test 9
20,000 cfs River / 3,000 cfs Pumped, GMF & Check Structure
#1,4 & 6 Bypasses Open
Approach Velocity, ft/s
Sweeping Velocity, ft/s
Maximun Targeted Approach Velocity
Minimum Targeted Sweeping Velocity
Velocity, ft/s
3.00
2.50
2.00
1.50
1.00
0.50
0.00
-0.50
-1.00
Bypass 6
Bypass 4
4 deg. bend
Bypass 1
4 deg. bend
0
100
200
300
400
500
600
700
800
900
1000
DS
Distance along the screen from downstream end, ft
US



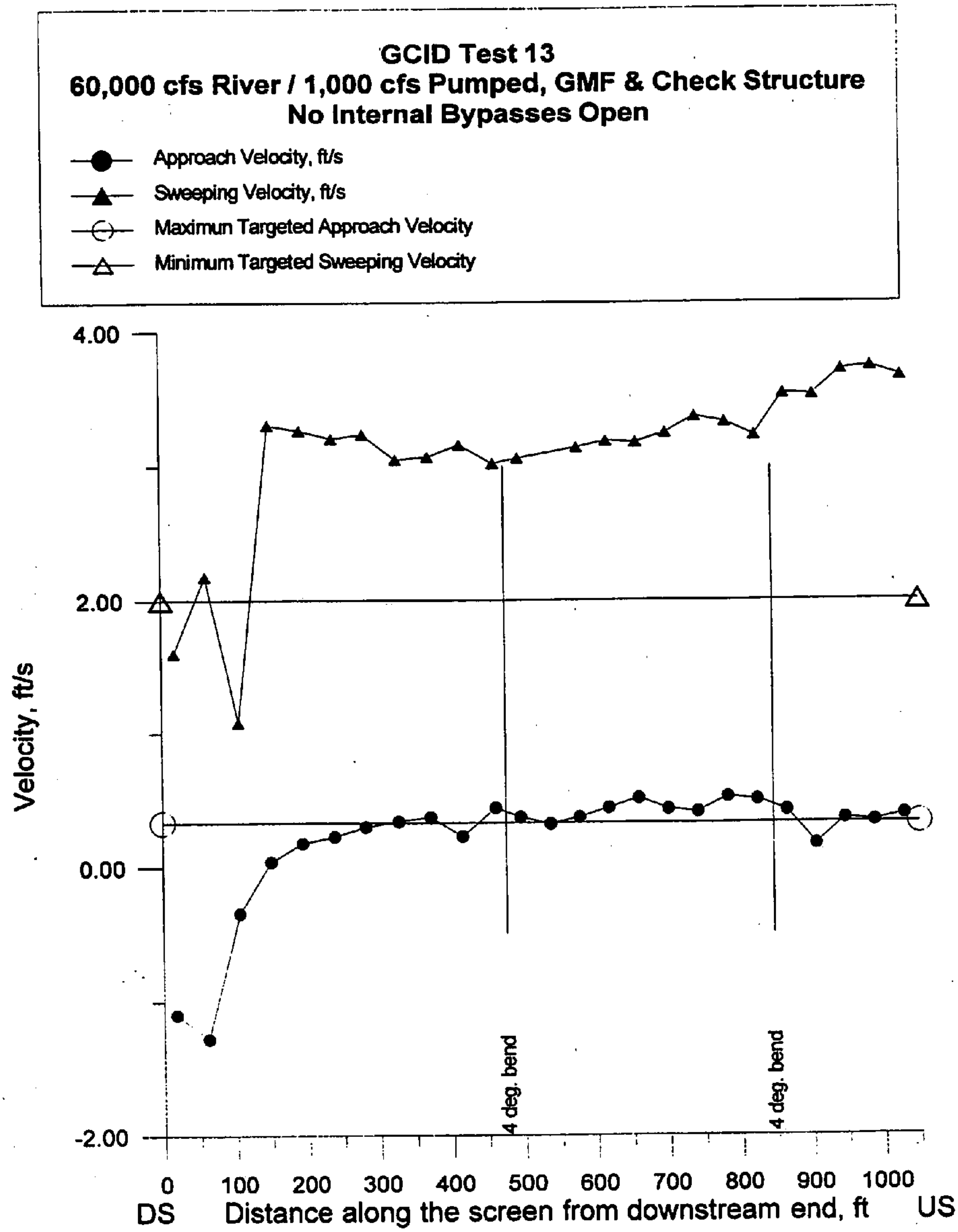
GCID Test 10
20,000 cfs River / 3,000 cfs Pumped, GMF & Check Structure
No Internal Bypasses Open
Approach Velocity, ft/s
Sweeping Velocity, ft/s
Maximun Targeted Approach Velocity
Minimum Targeted Sweeping Velocity
Velocity, ft/s
3.00
2.50
2.00
1.50
1.00
0.50
0.00
-0.50
-1.00
4 deg. bend
4 deg. bend
0
100
200
300
400
500
600
700
800
900
1000
DS
Distance along the screen from downstream end, ft
US



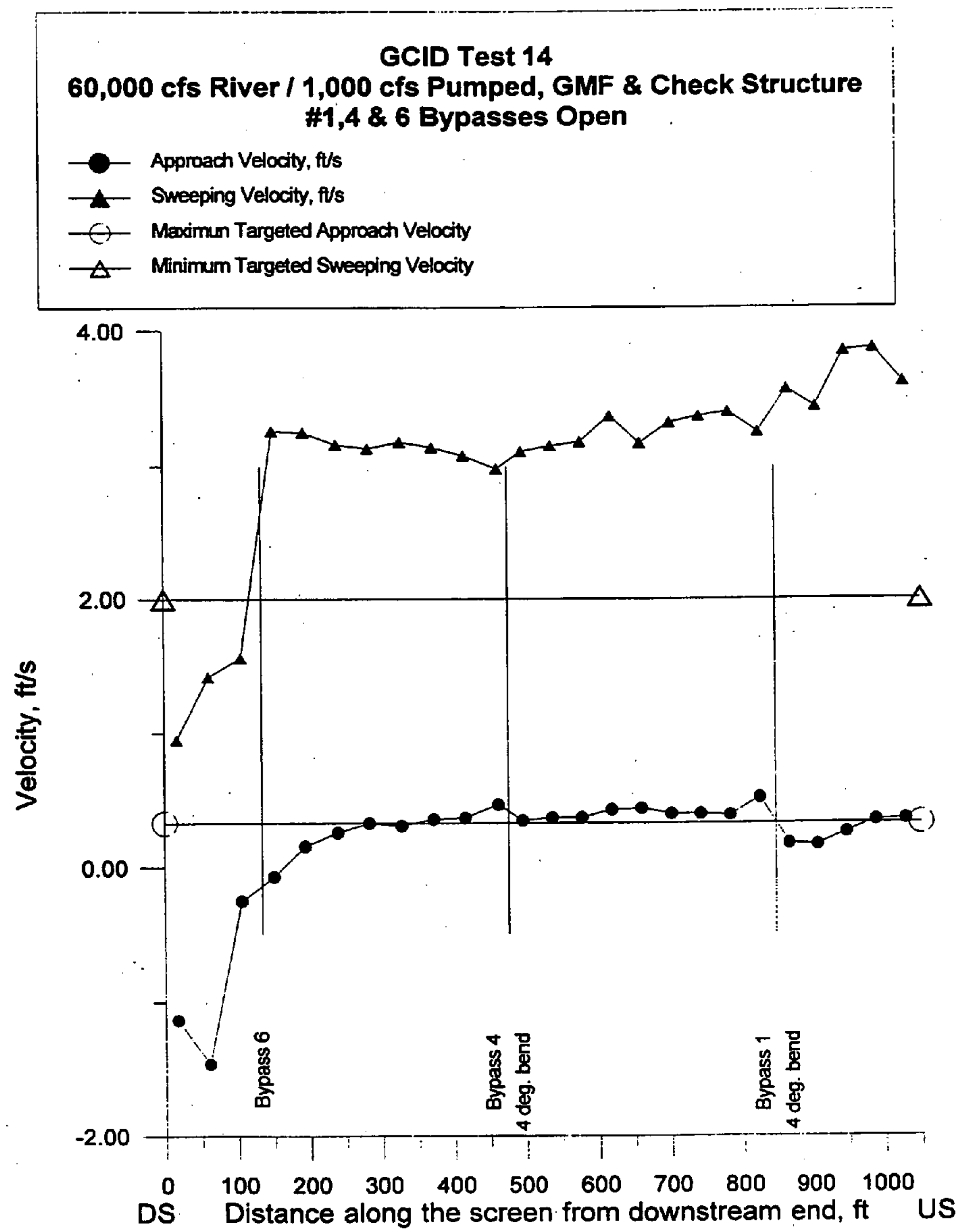
GCID Test 11
40,000 cfs River / 3,000 cfs Pumped, GMF & Check Structure
#1,4 & 6 Bypasses Open
Approach Velocity, ft/s
Sweeping Velocity, ft/s
Maximun Targeted Approach Velocity
Minimum Targeted Sweeping Velocity
4.00
2.00
0.00
-2.00
Velocity, ft/s
Bypass 6
Bypass 4
4 deg. bend
Bypass 1
4 deg. bend
0
100
200
300
400
500
600
700
800
900
1000
DS
Distance along the screen from downstream end, ft
US

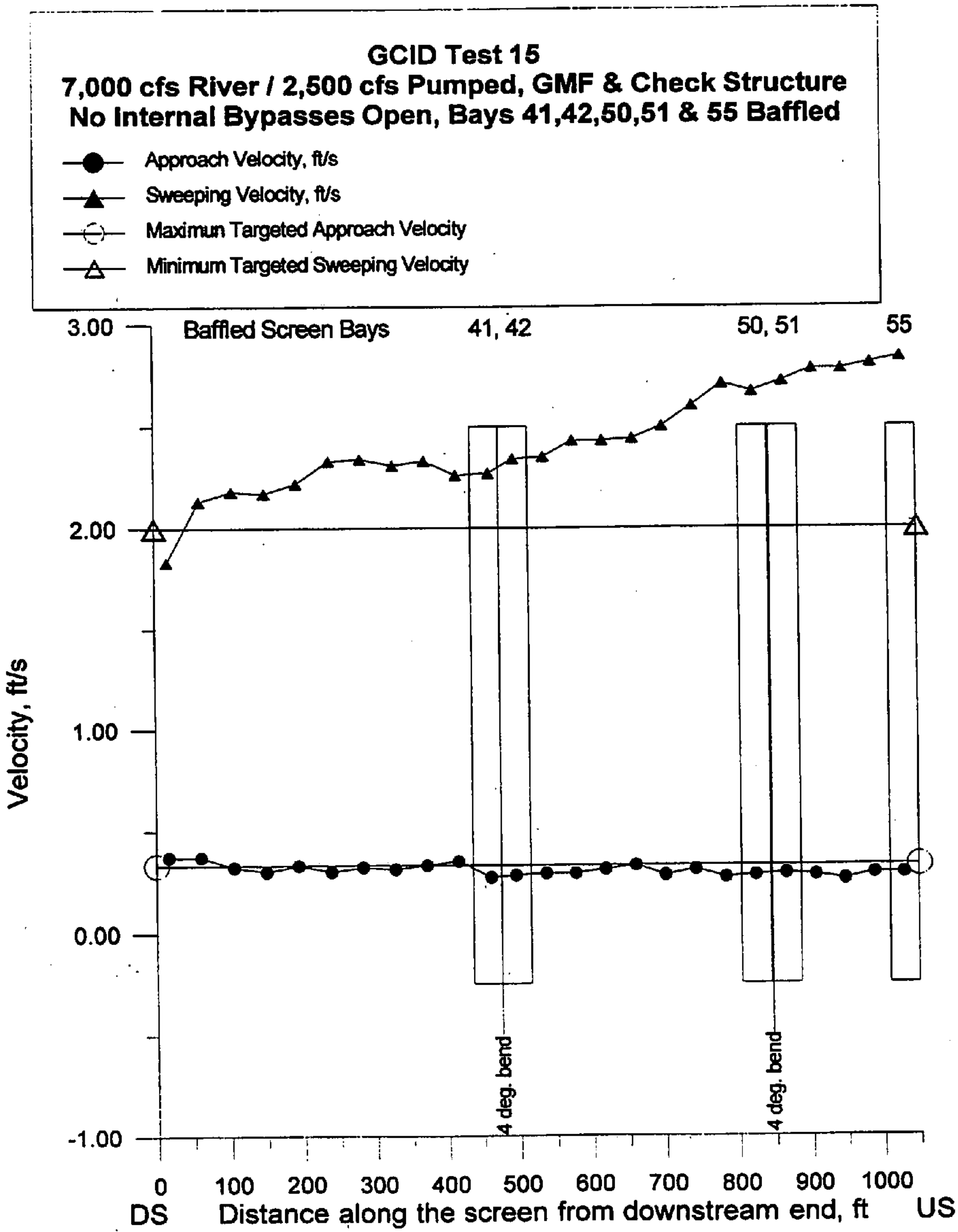


GCID Test 12
40,000 cfs River / 3,000 cfs Pumped, GMF & Check Structure
No Internal Bypasses Open
Approach Velocity, ft/s
Sweeping Velocity, ft/s
Maximun Targeted Approach Velocity
Minimum Targeted Sweeping Velocity
4.00
2.00
0.00
-2.00
Velocity, ft/s
4 deg. bend
4 deg. bend
0
100
200
300
400
500
600
700
800
900
1000
DS
Distance along the screen from downstream end, ft
US

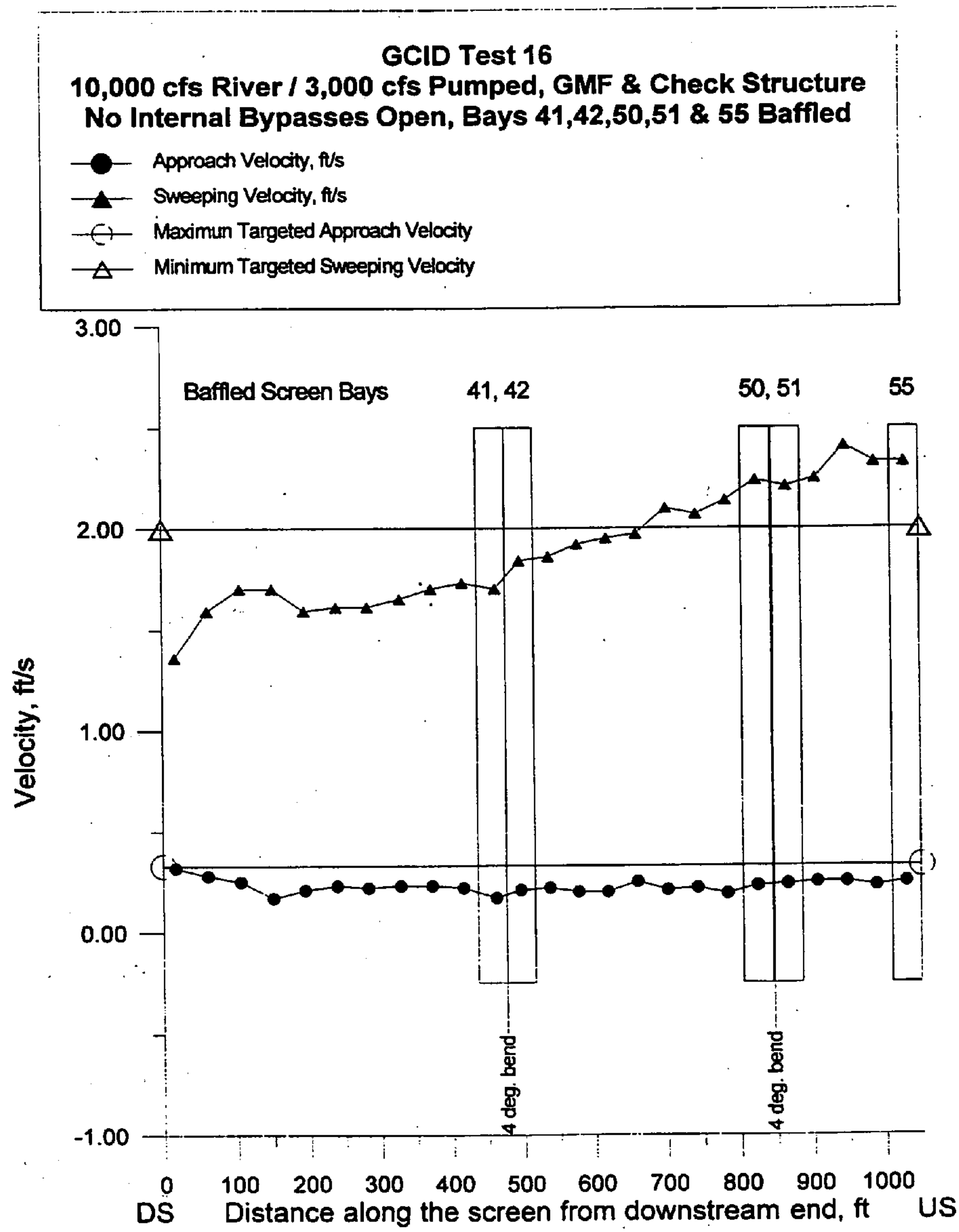


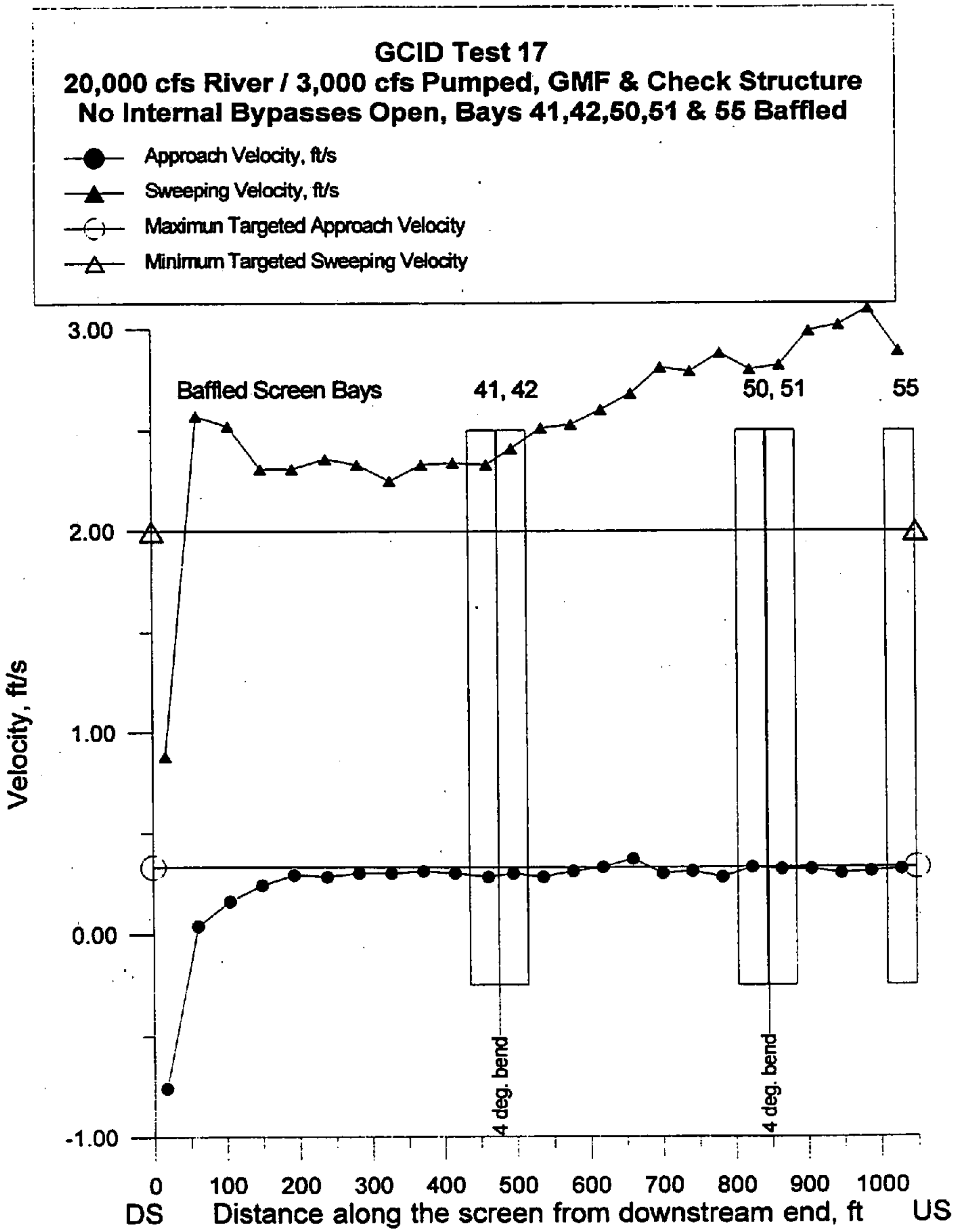
GCID Test 13
60,000 cfs River / 1,000 cfs Pumped, GMF & Check Structure
No Internal Bypasses Open
Approach Velocity, ft/s
Sweeping Velocity, ft/s
Maximun Targeted Approach Velocity
Minimum Targeted Sweeping Velocity
4.00
2.00
0.00
-2.00
Velocity, ft/s
4 deg. bend
4 deg. bend
0
100
200
300
400
500
600
700
800
900
1000
DS
Distance along the screen from downstream end, ft
US

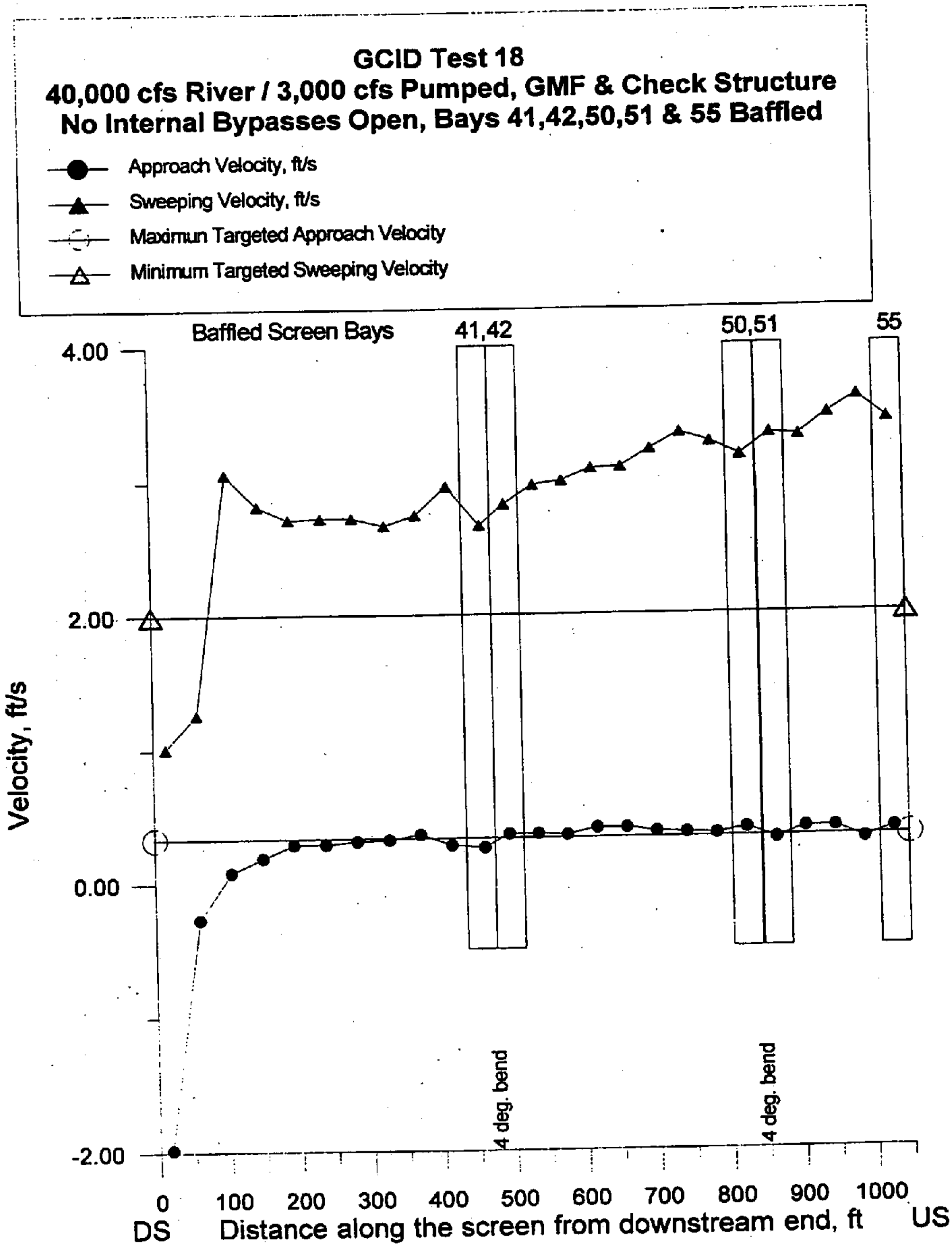

GCID Test 14
60,000 cfs River / 1,000 cfs Pumped, GMF & Check Structure
#1,4 & 6 Bypasses Open
Approach Velocity, ft/s
Sweeping Velocity, ft/s
Maximun Targeted Approach Velocity
Minimum Targeted Sweeping Velocity
4.00
2.00
0.00
-2.00
Velocity, ft/s
Bypass 6
Bypass 4
4 deg. bend
Bypass 1
4 deg. bend
0
100
200
300
400
500
600
700
800
900
1000
DS
Distance along the screen from downstream end, ft
US

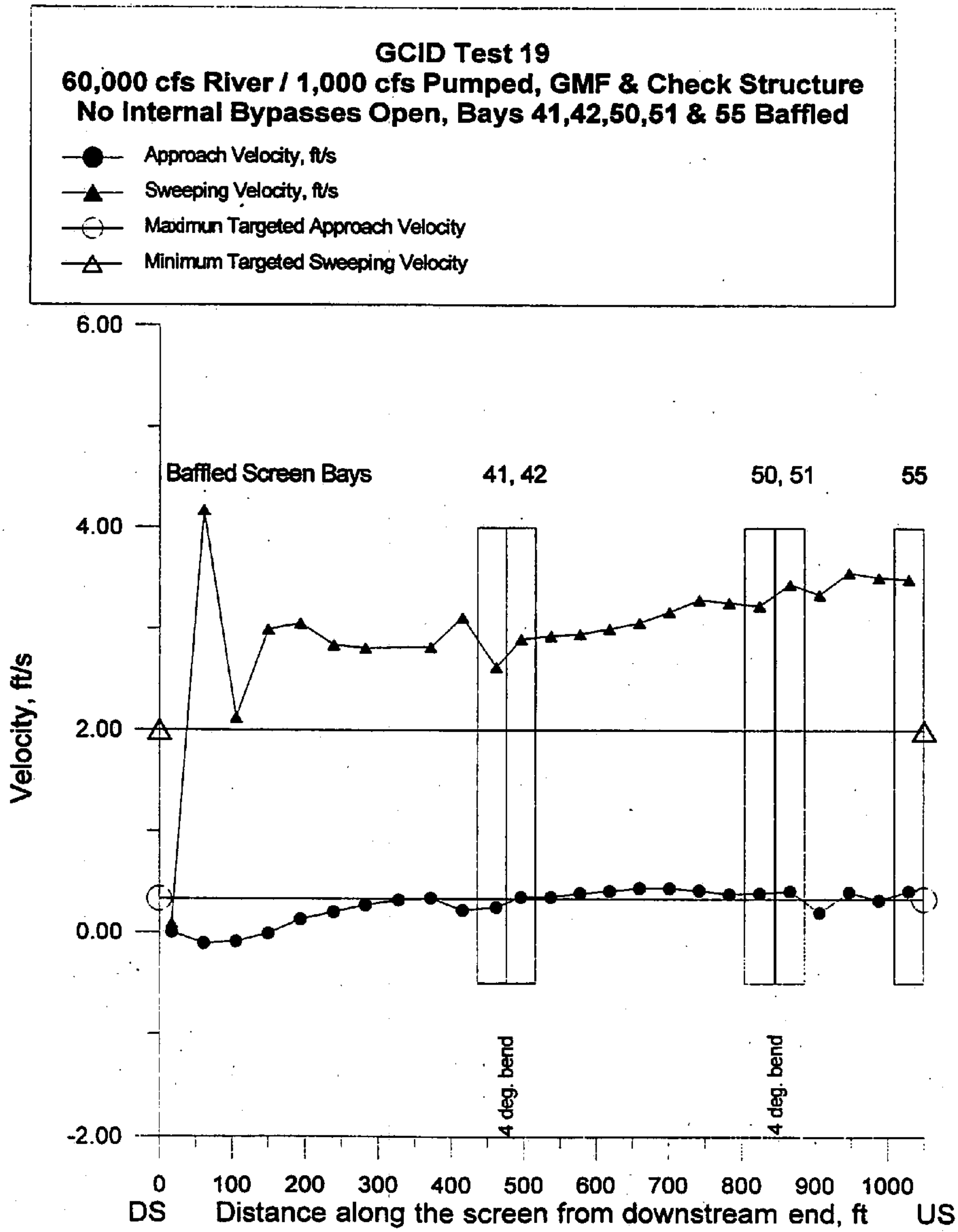


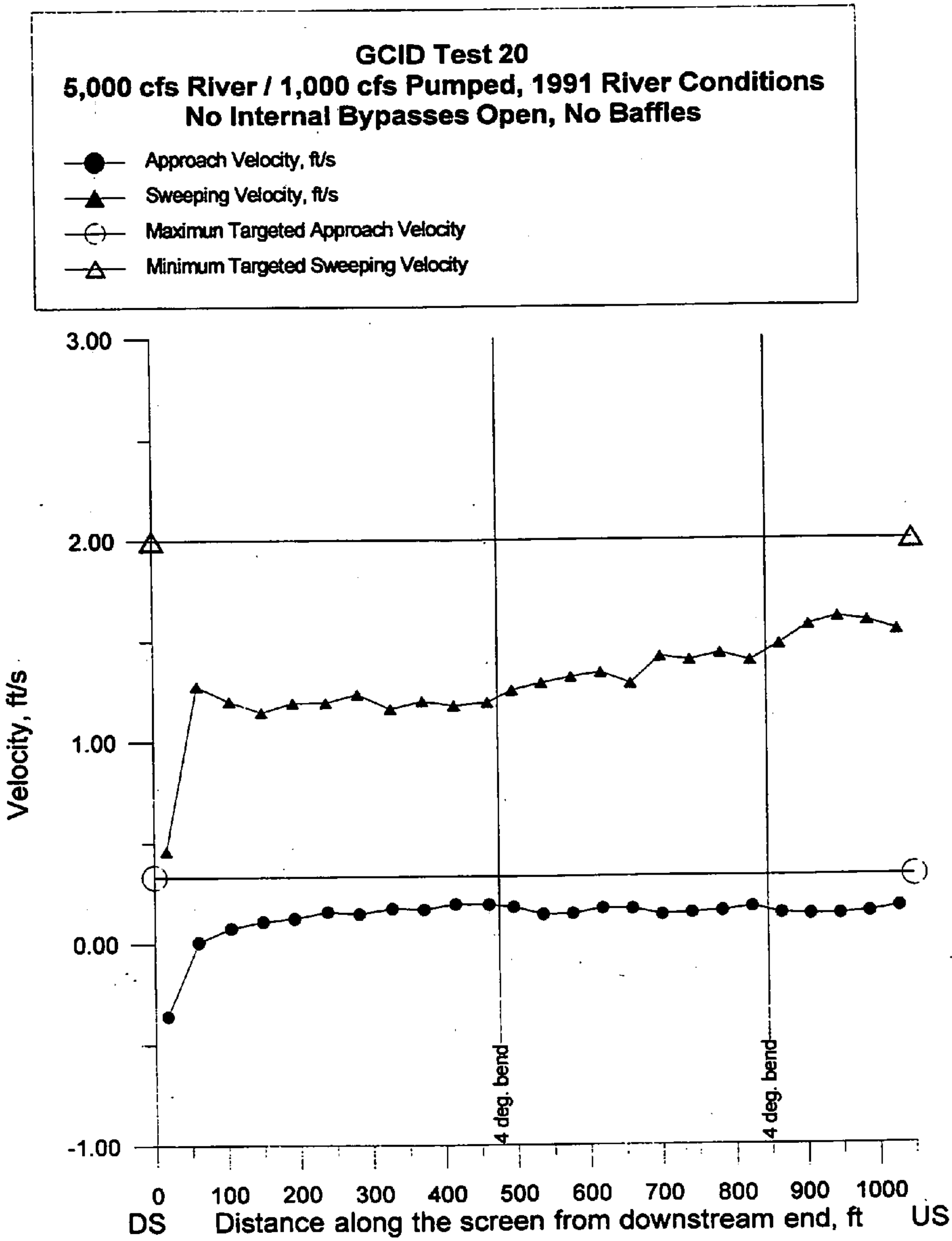
GCID Test 15
7,000 cfs River / 2,500 cfs Pumped, GMF & Check Structure
No Internal Bypasses Open, Bays 41,42,50,51 & 55 Baffled
Approach Velocity, ft/s
Sweeping Velocity, ft/s
Maximun Targeted Approach Velocity
Minimum Targeted Sweeping Velocity
Baffled Screen Bays
41, 42
50, 51
55
3.00
2.00
1.00
0.00
-1.00
Velocity, ft/s
4 deg. bend
4 deg. bend
0
100
200
300
400
500
600
700
800
900
1000
DS
Distance along the screen from downstream end, ft
US

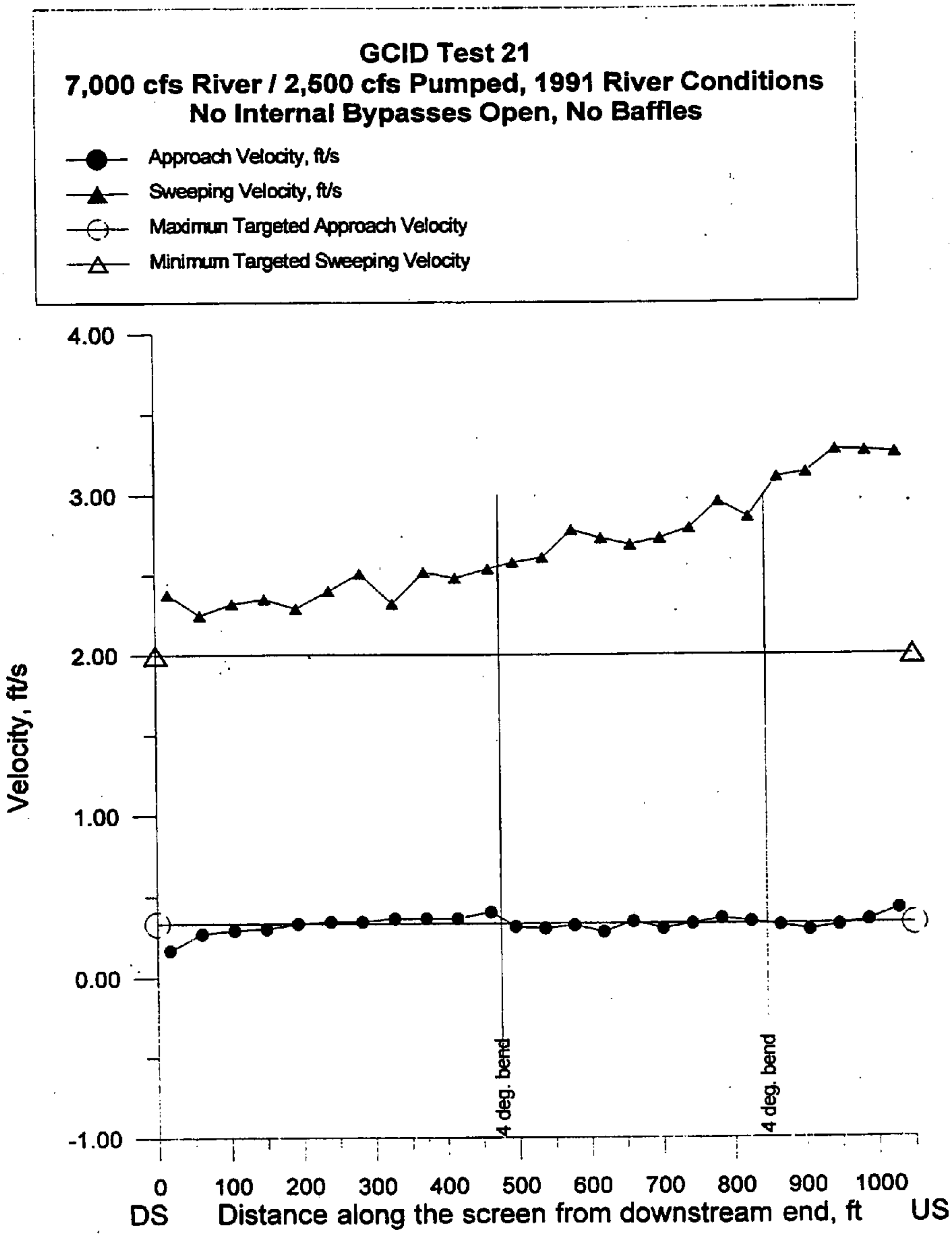

GCID Test 16
10,000 cfs River / 3,000 cfs Pumped, GMF & Check Structure
No Internal Bypasses Open, Bays 41,42,50,51 & 55 Baffled
Approach Velocity, ft/s
Sweeping Velocity, ft/s
Maximun Targeted Approach Velocity
Minimum Targeted Sweeping Velocity
Baffled Screen Bays
41, 42
50, 51
55
3.00
2.00
1.00
0.00
-1.00
Velocity, ft/s
4 deg. bend
4 deg. bend
0
100
200
300
400
500
600
700
800
900
1000
DS
Distance along the screen from downstream end, ft
US

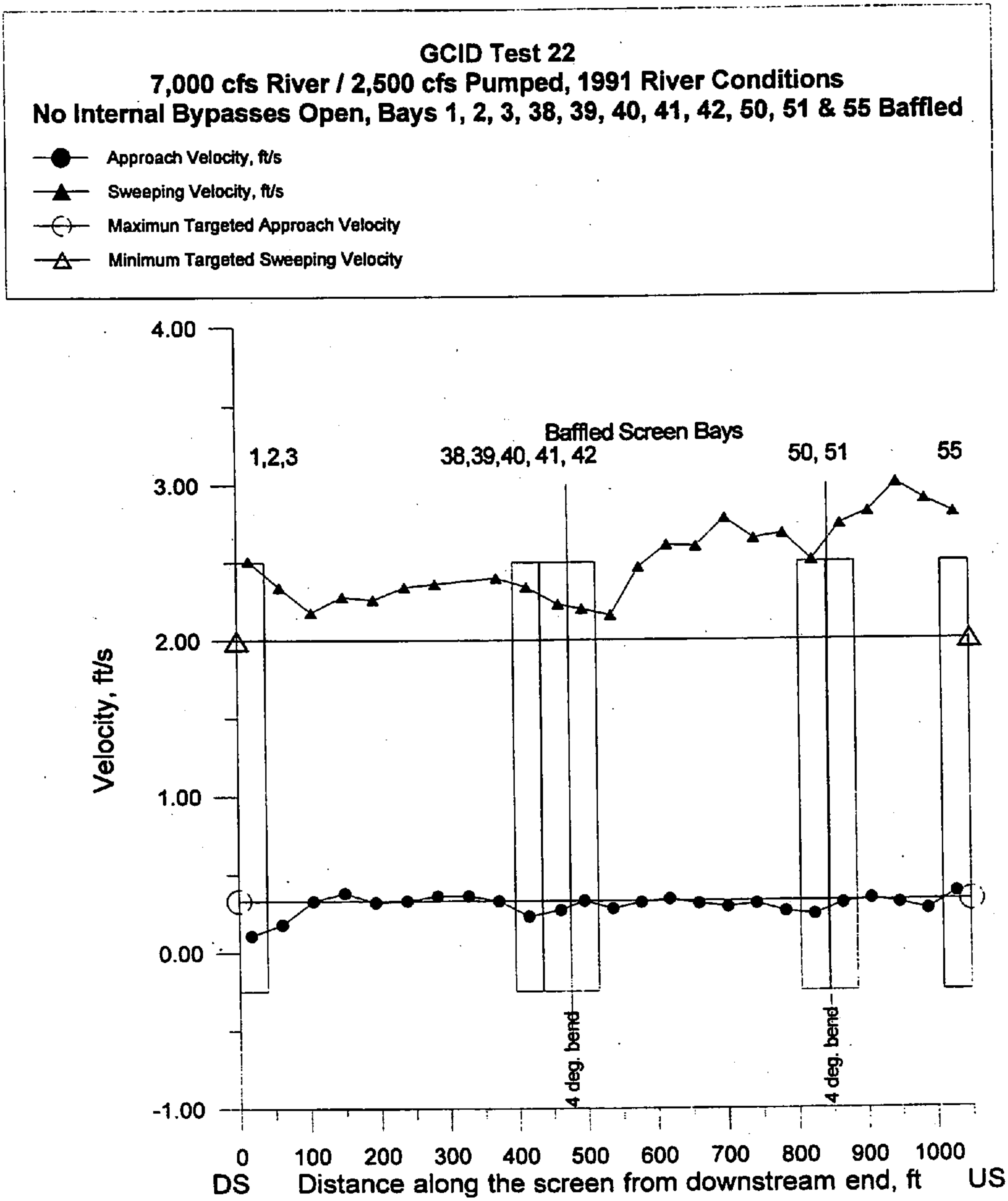

GCID Test 17
20,000 cfs River / 3,000 cfs Pumped, GMF & Check Structure
No Internal Bypasses Open, Bays 41,42,50,51 & 55 Baffled
Approach Velocity, ft/s
Sweeping Velocity, ft/s
Maximun Targeted Approach Velocity
Minimum Targeted Sweeping Velocity
Baffled Screen Bays
41, 42
50, 51
55
4 deg. bend
4 deg. bend
Velocity, ft/s
3.00
2.00
1.00
0.00
-1.00
0
100
200
300
400
500
600
700
800
900
1000
DS
Distance along the screen from downstream end, ft
US


GCID Test 18
40,000 cfs River / 3,000 cfs Pumped, GMF & Check Structure
No Internal Bypasses Open, Bays 41,42,50,51 & 55 Baffled
Approach Velocity, ft/s
Sweeping Velocity, ft/s
Maximun Targeted Approach Velocity
Minimum Targeted Sweeping Velocity
Baffled Screen Bays
41,42
50,51
55
4.00
2.00
0.00
-2.00
Velocity, ft/s
4 deg. bend
4 deg. bend
0
100
200
300
400
500
600
700
800
900
1000
DS
Distance along the screen from downstream end, ft
US

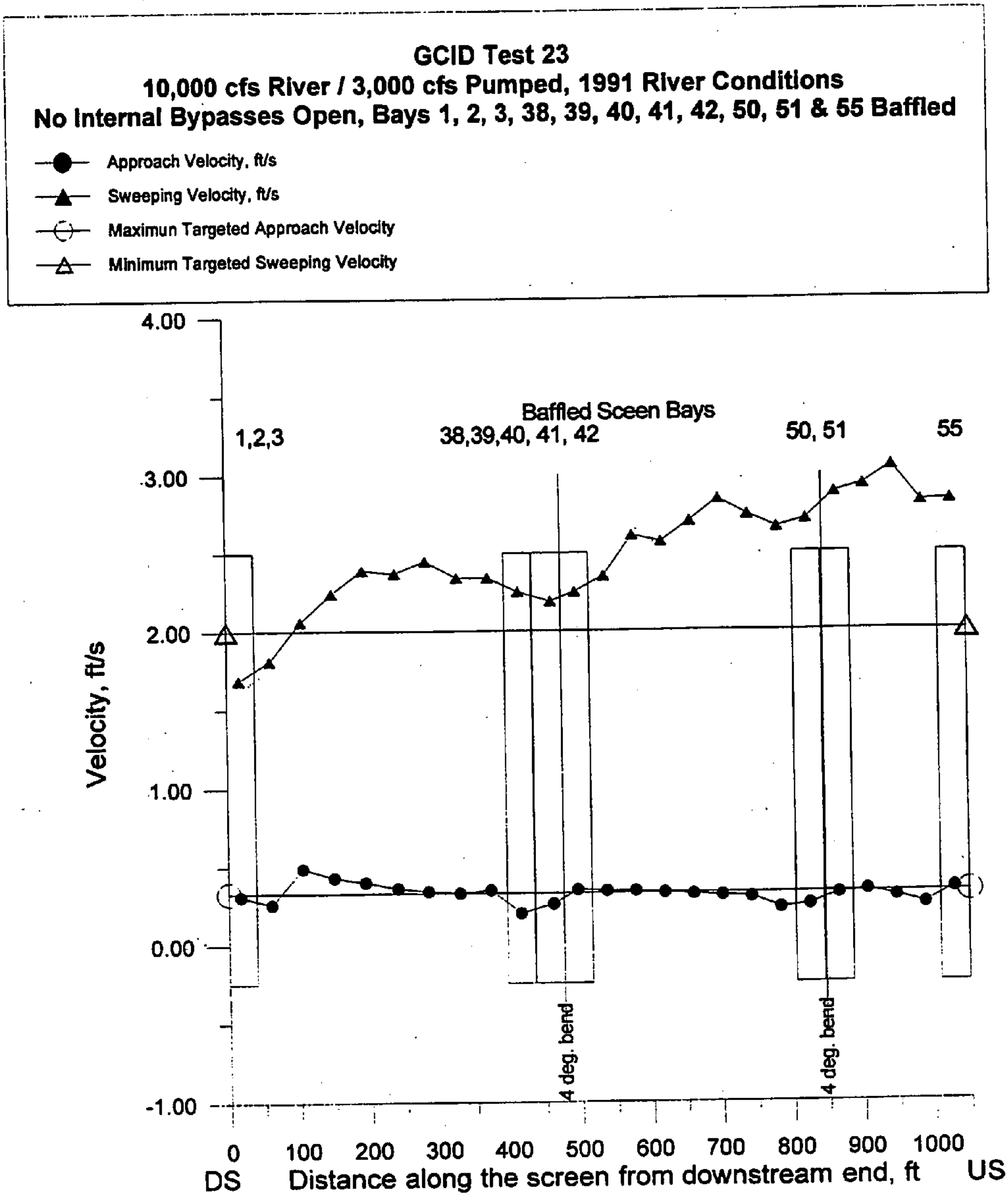

GCID Test 19
60,000 cfs River / 1,000 cfs Pumped, GMF & Check Structure
No Internal Bypasses Open, Bays 41,42,50,51 & 55 Baffled
Approach Velocity, ft/s
Sweeping Velocity, ft/s
Maximun Targeted Approach Velocity
Minimum Targeted Sweeping Velocity
Baffled Screen Bays
41, 42
50, 51
55
Velocity, ft/s
6.00
4.00
2.00
0.00
-2.00
4 deg. bend
4 deg. bend
0
100
200
300
400
500
600
700
800
900
1000
DS
Distance along the screen from downstream end, ft
US

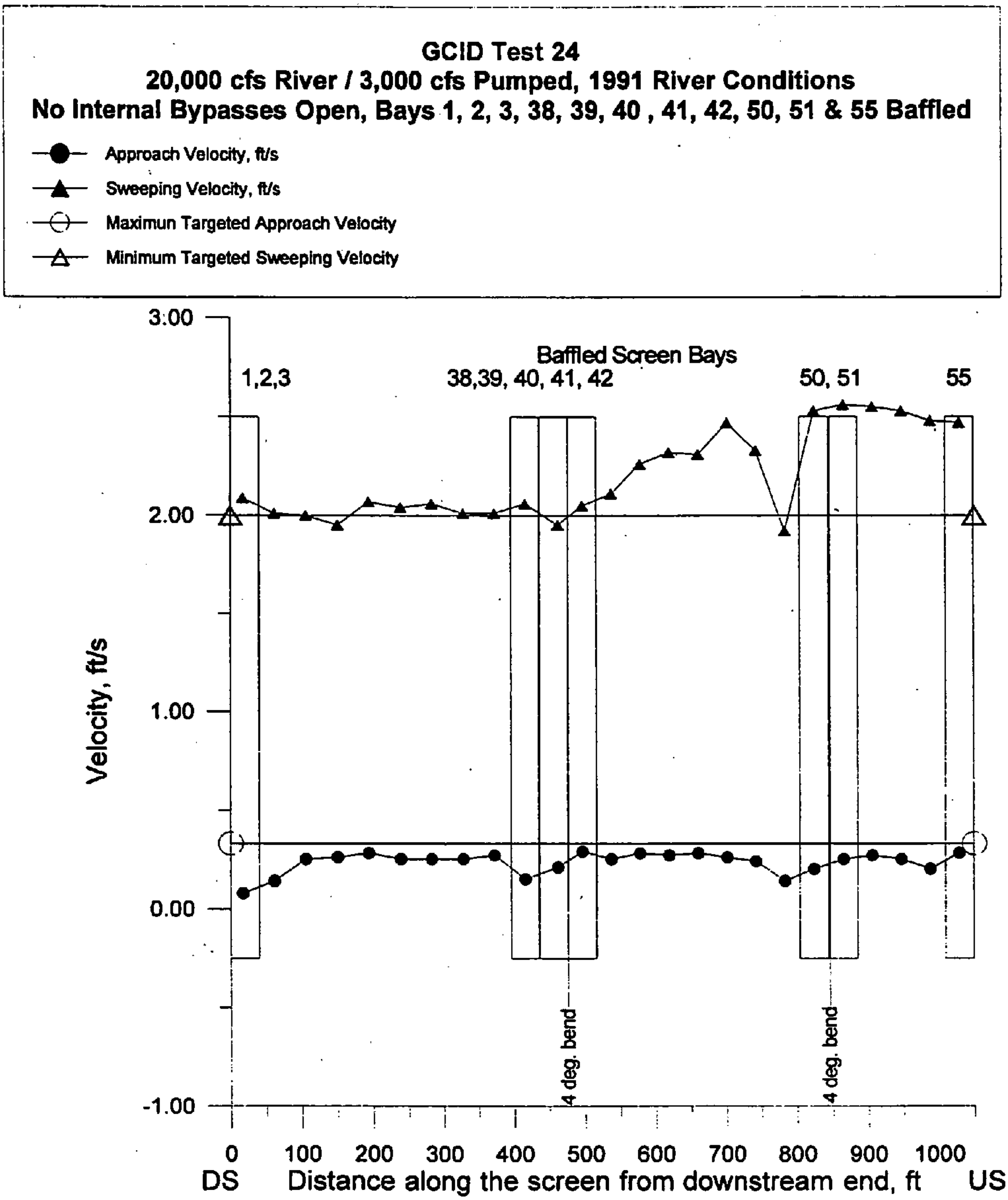

GCID Test 20
5,000 cfs River / 1,000 cfs Pumped, 1991 River Conditions
No Internal Bypasses Open, No Baffles
Approach Velocity, ft/s
Sweeping Velocity, ft/s
Maximun Targeted Approach Velocity
Minimum Targeted Sweeping Velocity
3.00
2.00
1.00
0.00
-1.00
Velocity, ft/s
4 deg. bend
4 deg. bend
0
100
200
300
400
500
600
700
800
900
1000
DS
Distance along the screen from downstream end, ft
US

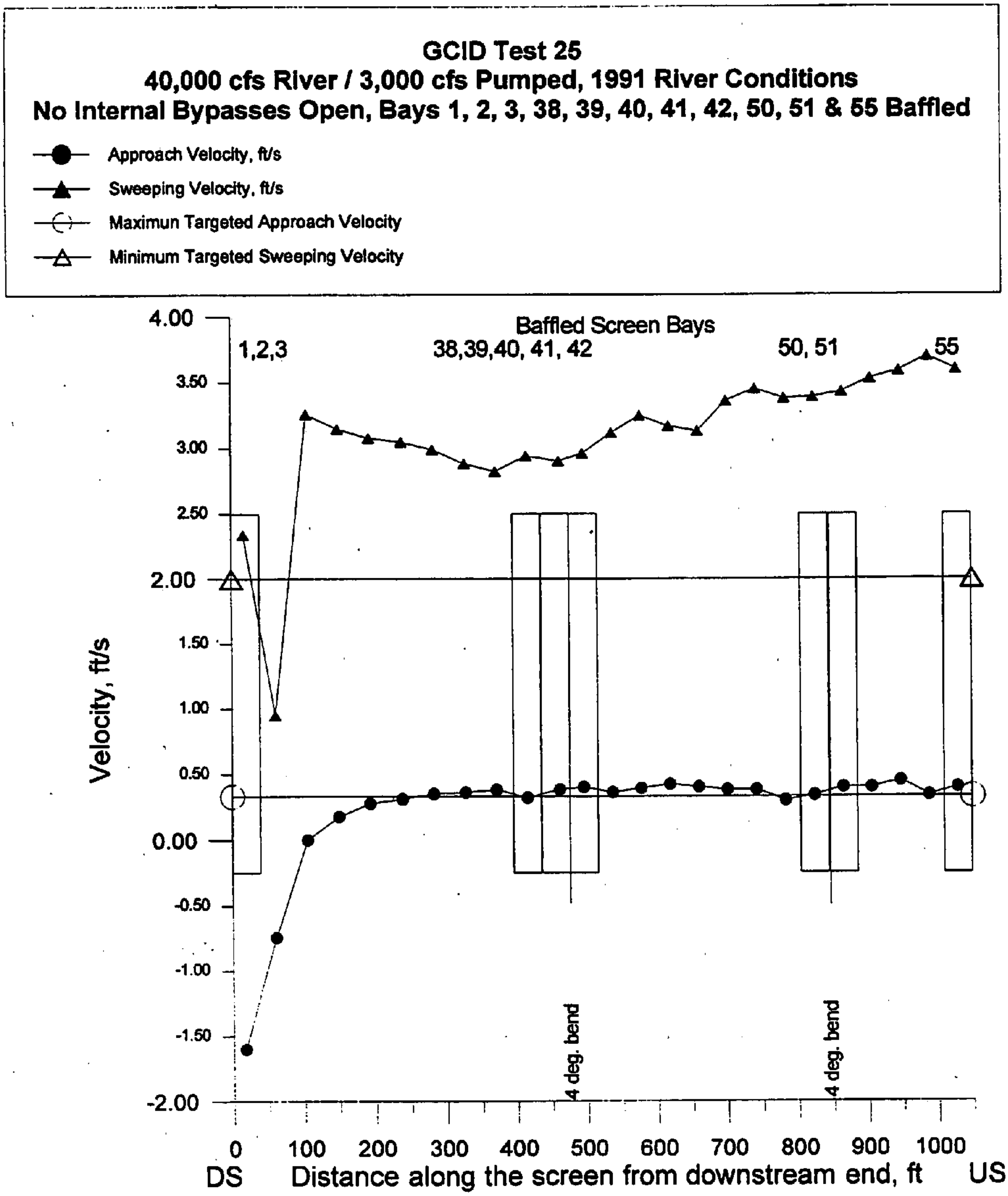

GCID Test 21
7,000 cfs River / 2,500 cfs Pumped, 1991 River Conditions
No Internal Bypasses Open, No Baffles
Approach Velocity, ft/s
Sweeping Velocity, ft/s
Maximun Targeted Approach Velocity
Minimum Targeted Sweeping Velocity
4.00
3.00
2.00
1.00
0.00
-1.00
Velocity, ft/s
4 deg. bend
4 deg. bend
0
100
200
300
400
500
600
700
800
900
1000
DS
Distance along the screen from downstream end, ft
US

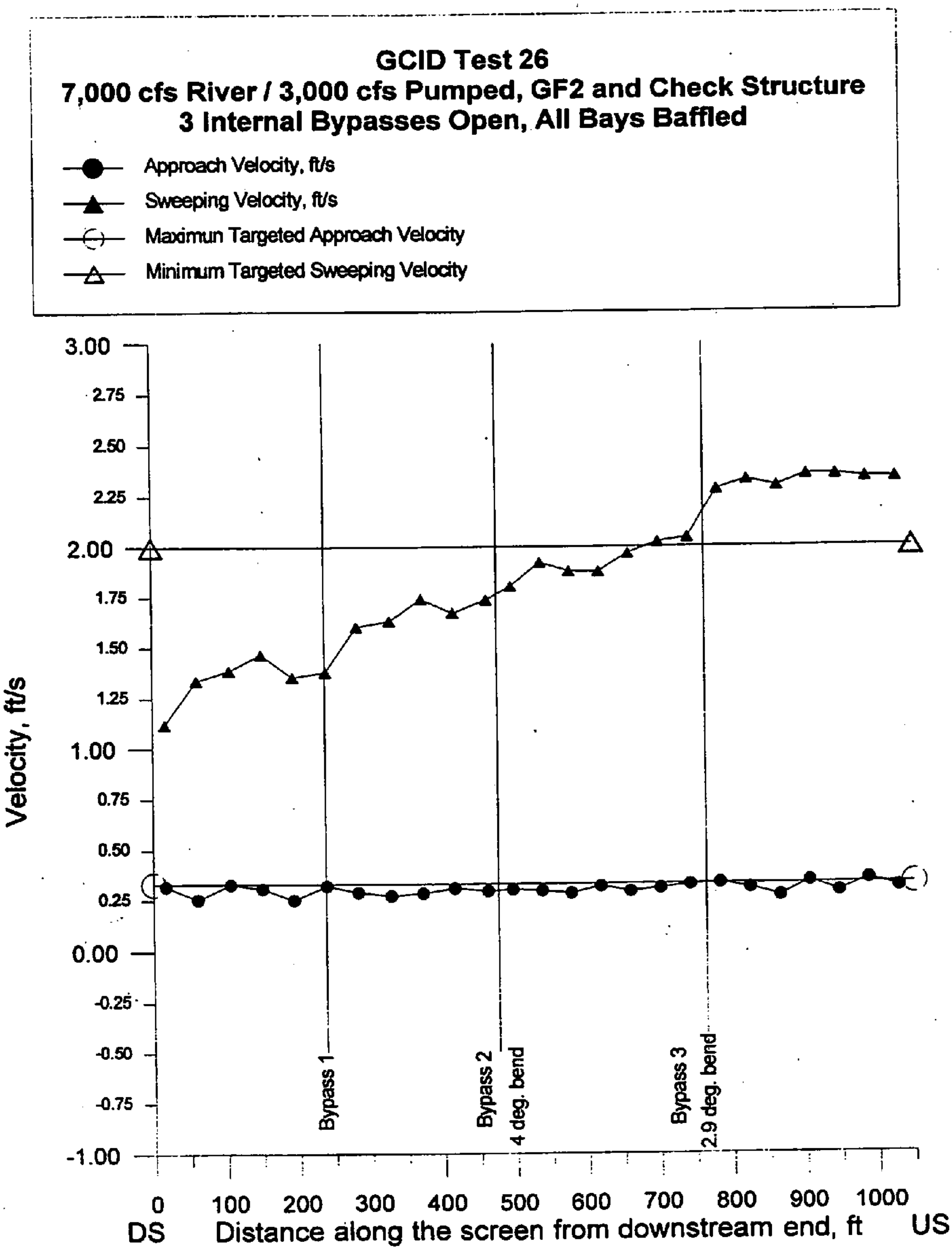


GCID Test 22
7,000 cfs River / 2,500 cfs Pumped, 1991 River Conditions
No Internal Bypasses Open, Bays 1, 2, 3, 38, 39, 40, 41, 42, 50, 51 & 55 Baffled
Approach Velocity, ft/s
Sweeping Velocity, ft/s
Maximun Targeted Approach Velocity
Minimum Targeted Sweeping Velocity
Baffled Screen Bays
1,2,3
38,39,40, 41, 42
50, 51
55
4 deg. bend
4 deg. bend
4.00
3.00
2.00
1.00
0.00
-1.00
Velocity, ft/s
0
100
200
300
400
500
600
700
800
900
1000
DS
Distance along the screen from downstream end, ft
US

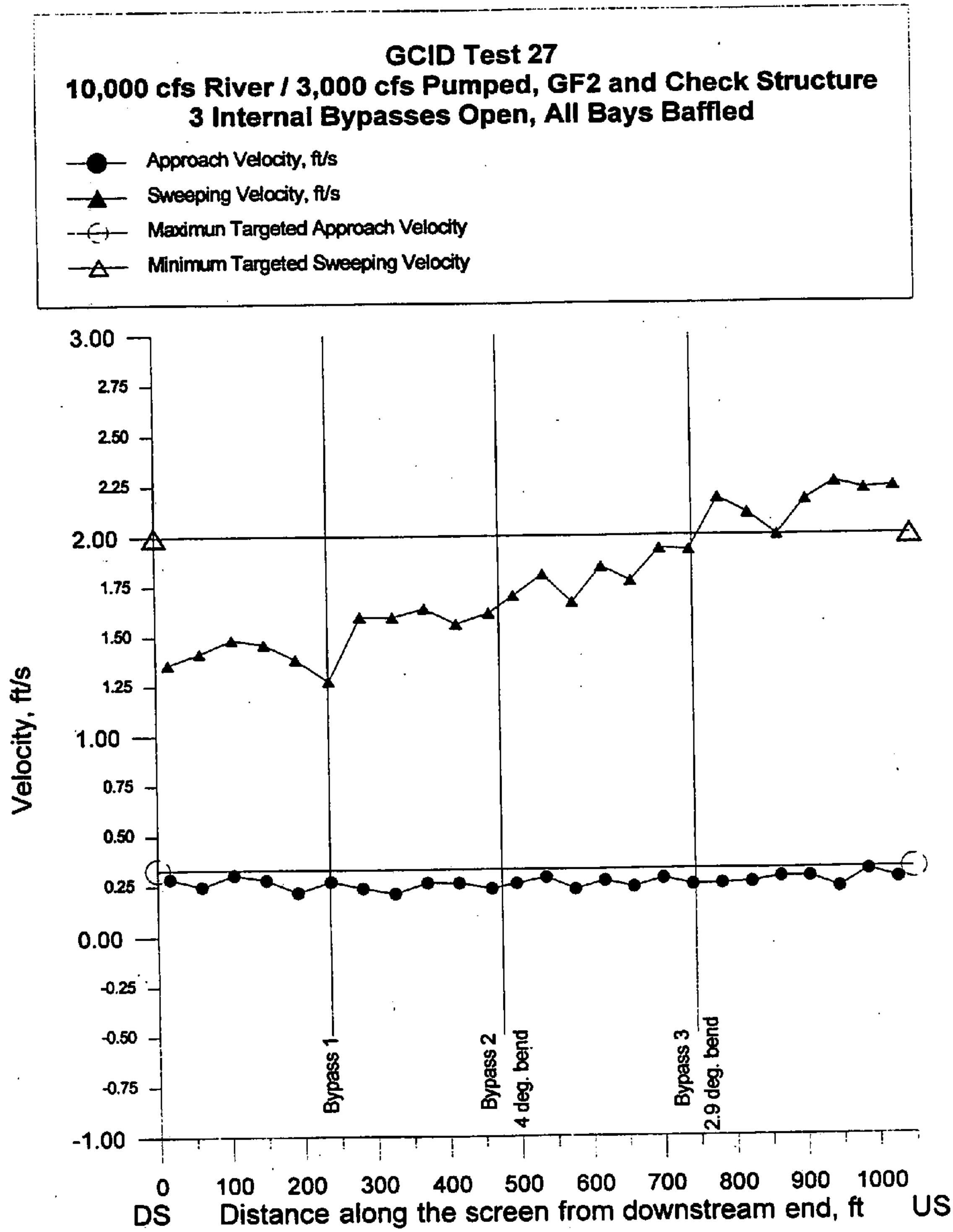

GCID Test 23
10,000 cfs River / 3,000 cfs Pumped, 1991 River Conditions
No Internal Bypasses Open, Bays 1, 2, 3, 38, 39, 40, 41, 42, 50, 51 & 55 Baffled
Approach Velocity, ft/s
Sweeping Velocity, ft/s
Maximun Targeted Approach Velocity
Minimum Targeted Sweeping Velocity
Baffled Sceen Bays
1,2,3
38,39,40, 41, 42
50, 51
55
4 deg. bend
4 deg. bend
Velocity, ft/s
4.00
3.00
2.00
1.00
0.00
-1.00
0
100
200
300
400
500
600
700
800
900
1000
DS
Distance along the screen from downstream end, ft
US


GCID Test 24
20,000 cfs River / 3,000 cfs Pumped, 1991 River Conditions
No Internal Bypasses Open, Bays 1, 2, 3, 38, 39, 40 , 41, 42, 50, 51 & 55 Baffled
Approach Velocity, ft/s
Sweeping Velocity, ft/s
Maximun Targeted Approach Velocity
Minimum Targeted Sweeping Velocity
Baffled Screen Bays
1,2,3
38,39, 40, 41, 42
50, 51
55
4 deg. bend
4 deg. bend
Velocity, ft/s
3.00
2.00
1.00
0.00
-1.00
0
100
200
300
400
500
600
700
800
900
1000
DS
Distance along the screen from downstream end, ft
US

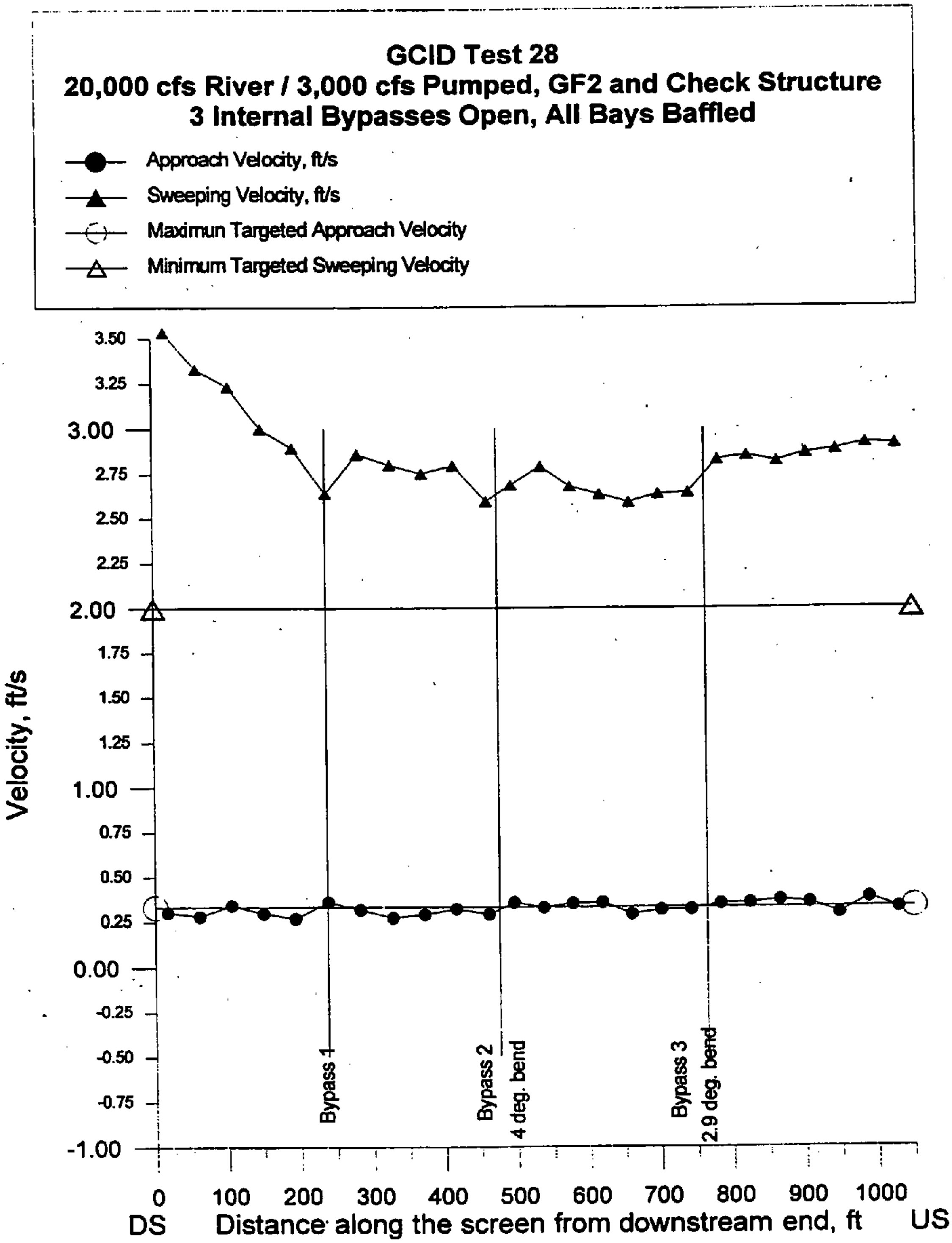

GCID Test 25
40,000 cfs River / 3,000 cfs Pumped, 1991 River Conditions
No Internal Bypasses Open, Bays 1, 2, 3, 38, 39, 40, 41, 42, 50, 51 & 55 Baffled
Approach Velocity, ft/s
Sweeping Velocity, ft/s
Maximun Targeted Approach Velocity
Minimum Targeted Sweeping Velocity
Baffled Screen Bays
1,2,3
38,39,40, 41, 42
50, 51
55
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
-0.50
-1.00
-1.50
-2.00
Velocity, ft/s
4 deg. bend
4 deg. bend
0
100
200
300
400
500
600
700
800
900
1000
DS
Distance along the screen from downstream end, ft
US

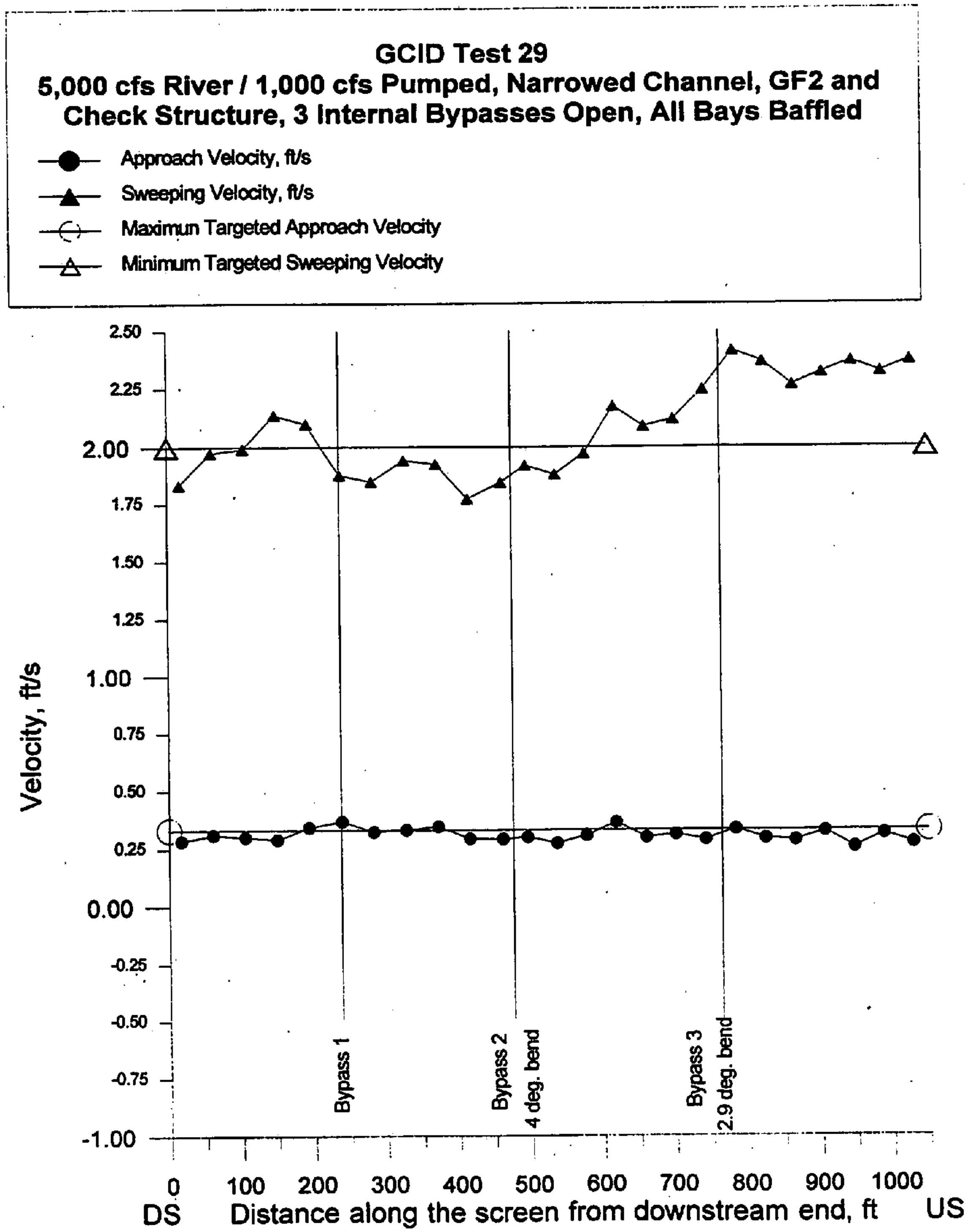


GCID Test 26
7,000 cfs River / 3,000 cfs Pumped, GF2 and Check Structure
3 Internal Bypasses Open, All Bays Baffled
Approach Velocity, ft/s
Sweeping Velocity, ft/s
Maximun Targeted Approach Velocity
Minimum Targeted Sweeping Velocity
Velocity, ft/s
3.00
2.75
2.50
2.25
2.00
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00
-0.25
-0.50
-0.75
-1.00
Bypass 1
Bypass 2
4 deg. bend
Bypass 3
2.9 deg. bend
0
100
200
300
400
500
600
700
800
900
1000
DS
Distance along the screen from downstream end, ft
US

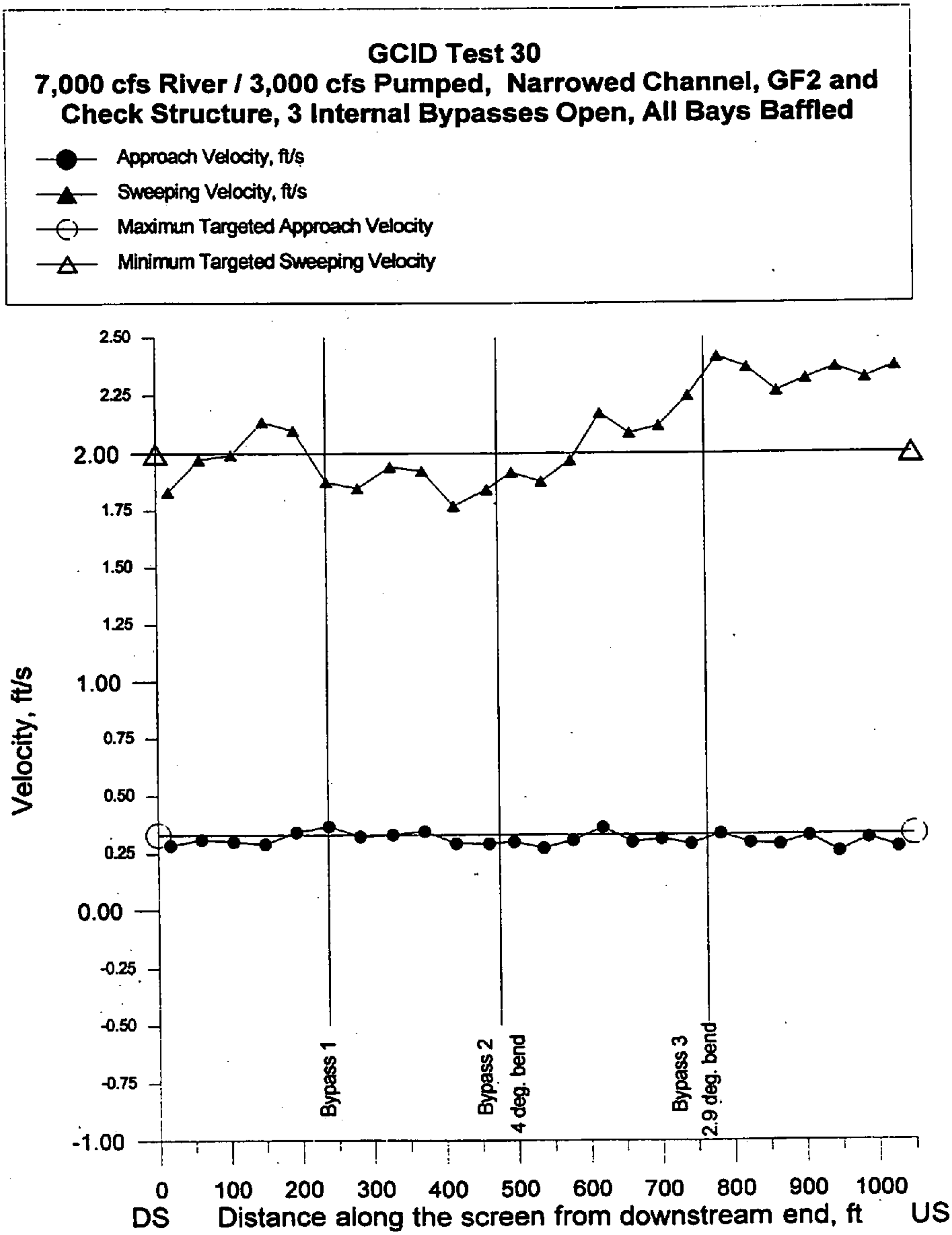


GCID Test 27
10,000 cfs River / 3,000 cfs Pumped, GF2 and Check Structure
3 Internal Bypasses Open, All Bays Baffled
Approach Velocity, ft/s
Sweeping Velocity, ft/s
Maximun Targeted Approach Velocity
Minimum Targeted Sweeping Velocity
Velocity, ft/s
3.00
2.75
2.50
2.25
2.00
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00
-0.25
-0.50
-0.75
-1.00
Bypass 1
Bypass 2
4 deg. bend
Bypass 3
2.9 deg. bend
0
100
200
300
400
500
600
700
800
900
1000
DS
Distance along the screen from downstream end, ft
US

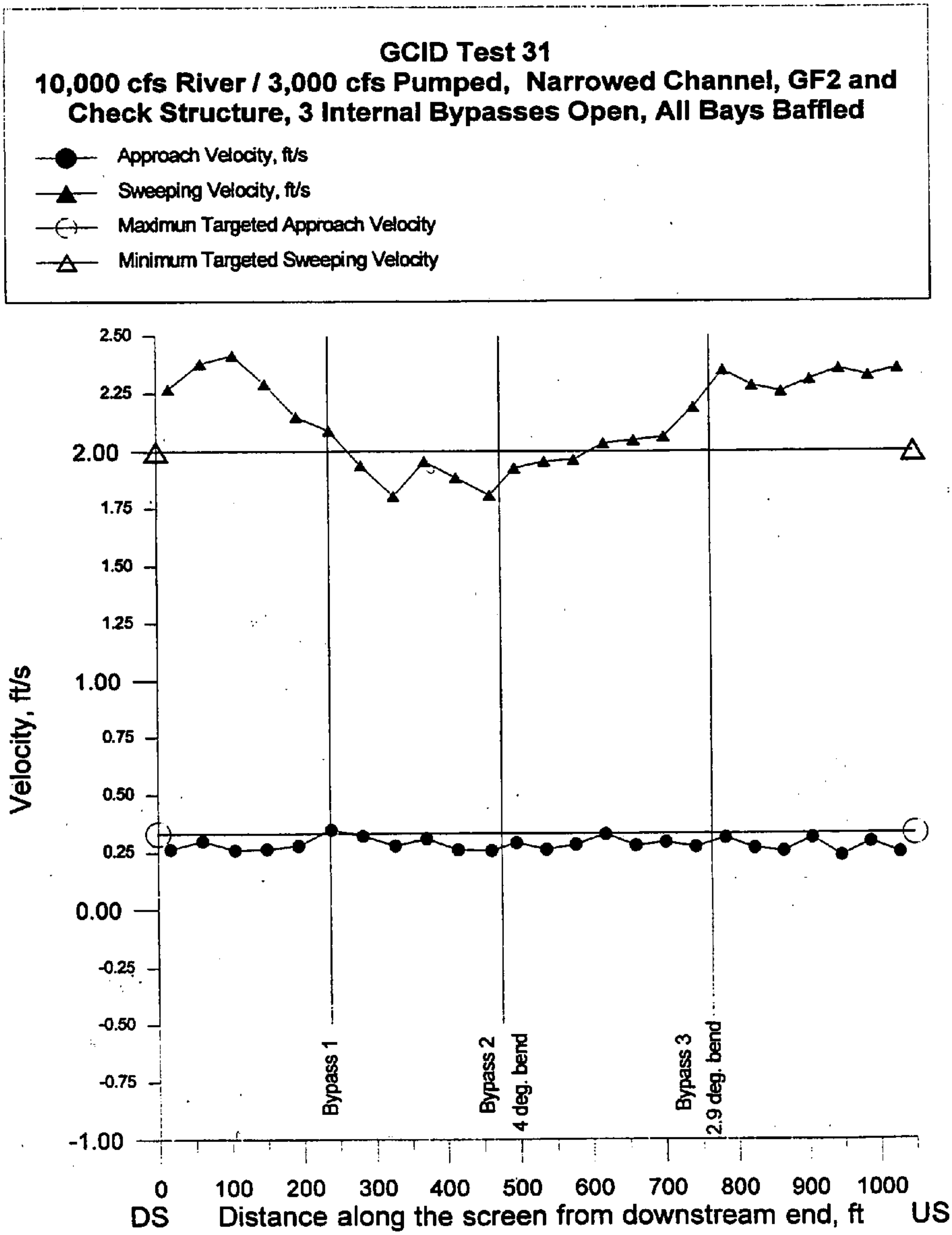

GCID Test 28
20,000 cfs River / 3,000 cfs Pumped, GF2 and Check Structure
3 Internal Bypasses Open, All Bays Baffled
Approach Velocity, ft/s
Sweeping Velocity, ft/s
Maximun Targeted Approach Velocity
Minimum Targeted Sweeping Velocity
Velocity, ft/s
3.50
3.25
3.00
2.75
2.50
2.25
2.00
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00
-0.25
-0.50
-0.75
-1.00
Bypass 1
Bypass 2
4 deg. bend
Bypass 3
2.9 deg. bend
0
100
200
300
400
500
600
700
800
900
1000
DS
Distance along the screen from downstream end, ft
US



GCID Test 29
5,000 cfs River / 1,000 cfs Pumped, Narrowed Channel, GF2 and Check Structure, 3 Internal Bypasses Open, All Bays Baffled
Approach Velocity, ft/s
Sweeping Velocity, ft/s
Maximun Targeted Approach Velocity
Minimum Targeted Sweeping Velocity
Velocity, ft/s
2.50
2.25
2.00
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00
-0.25
-0.50
-0.75
-1.00
Bypass 1
Bypass 2
4 deg. bend
Bypass 3
2.9 deg. bend
0
100
200
300
400
500
600
700
800
900
1000
DS
Distance along the screen from downstream end, ft
US

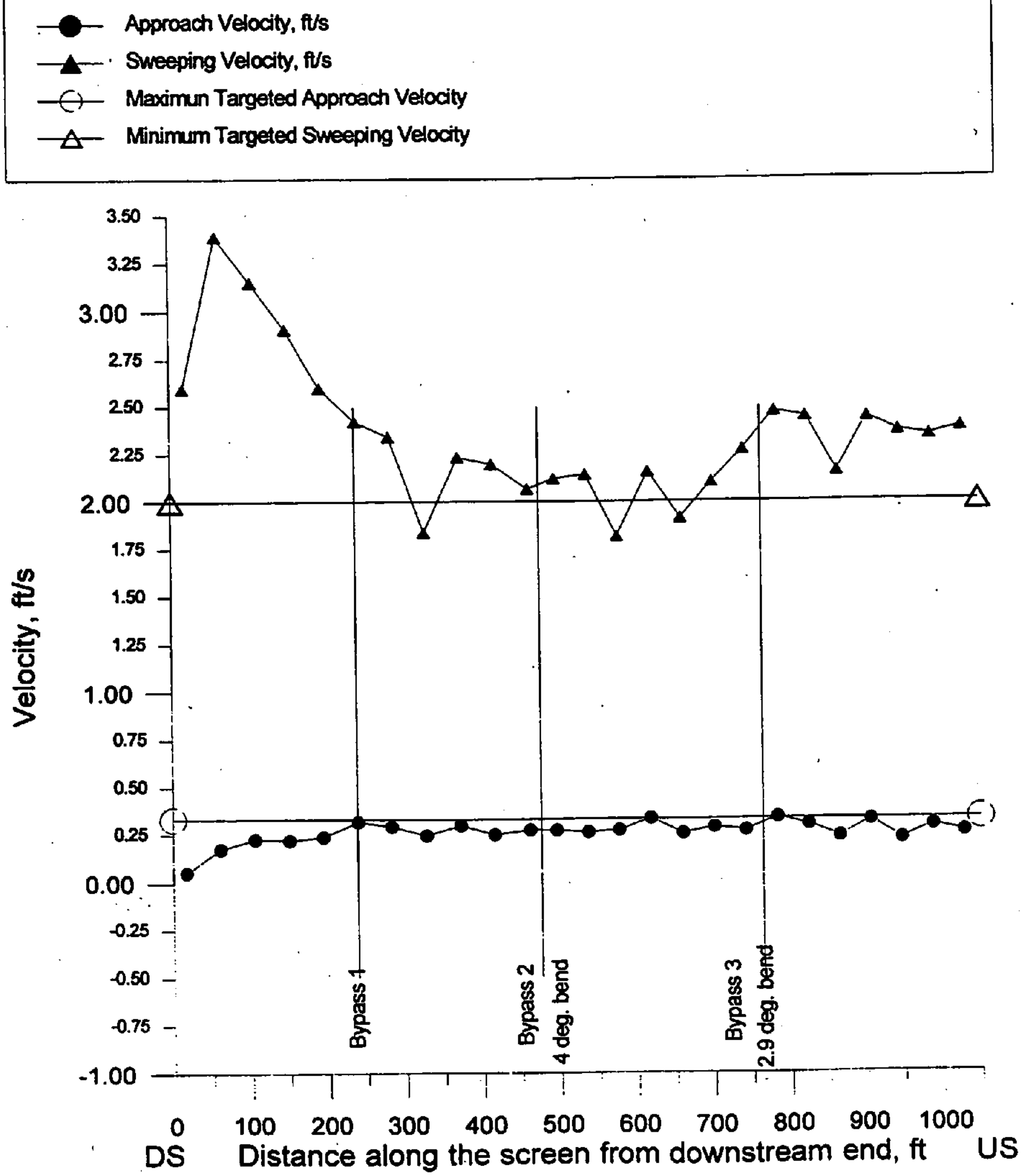


GCID Test 30
7,000 cfs River / 3,000 cfs Pumped, Narrowed Channel, GF2 and Check Structure, 3 Internal Bypasses Open, All Bays Baffled
Approach Velocity, ft/s
Sweeping Velocity, ft/s
Maximun Targeted Approach Velocity
Minimum Targeted Sweeping Velocity
Velocity, ft/s
2.50
2.25
2.00
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00
-0.25
-0.50
-0.75
-1.00
Bypass 1
Bypass 2
4 deg. bend
Bypass 3
2.9 deg. bend
0
100
200
300
400
500
600
700
800
900
1000
DS
Distance along the screen from downstream end, ft
US

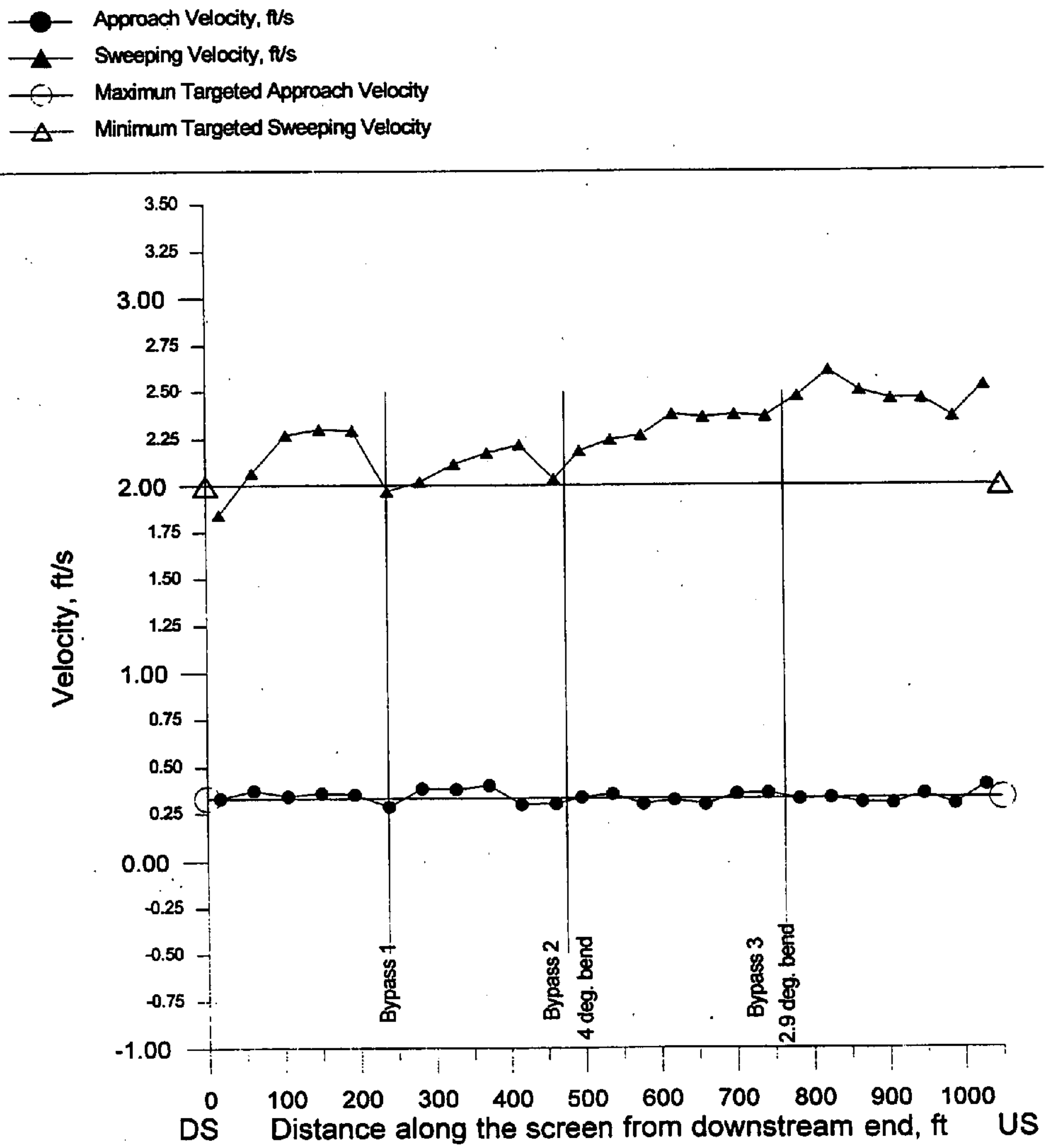


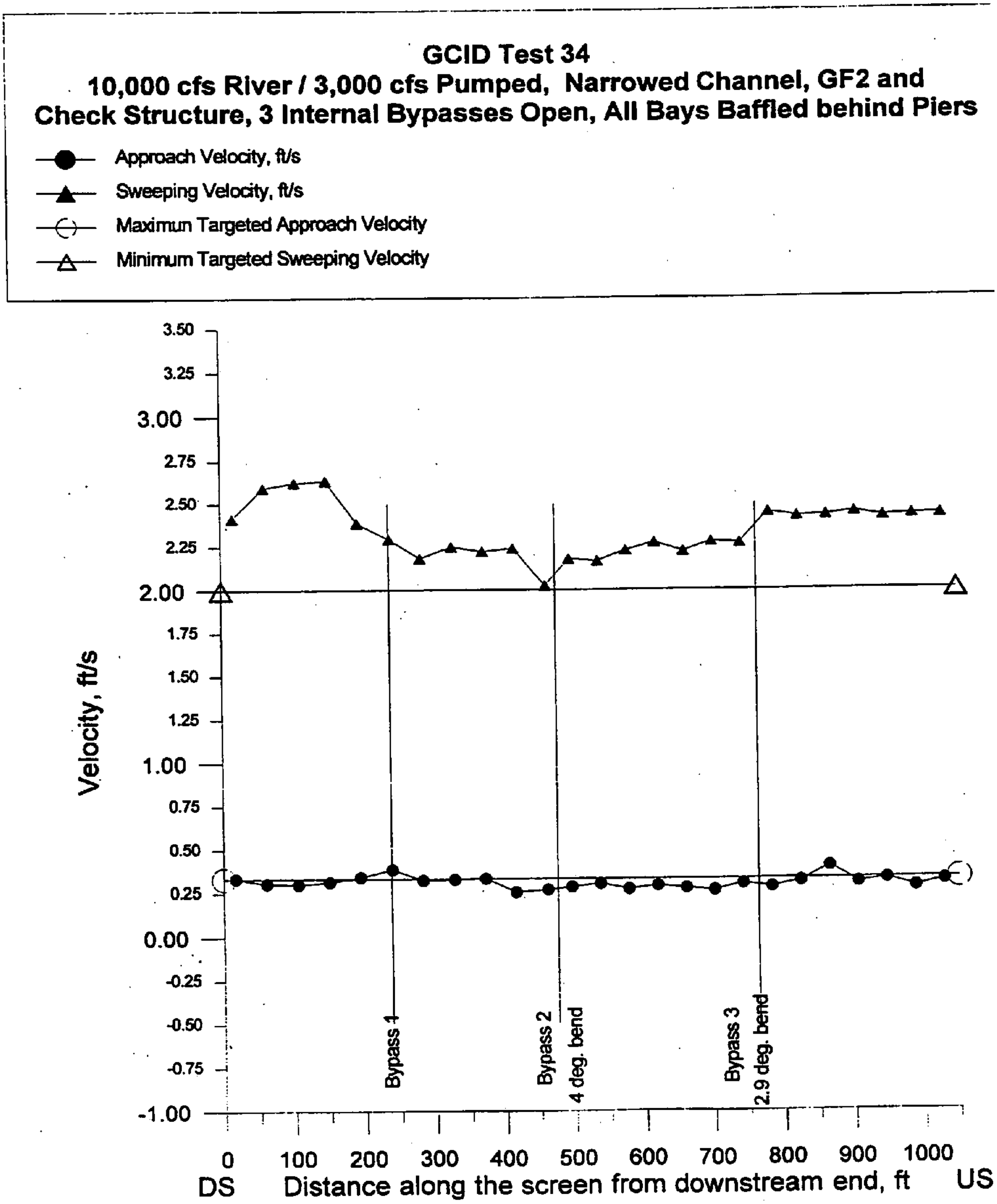
GCID Test 31
10,000 cfs River / 3,000 cfs Pumped, Narrowed Channel, GF2 and Check Structure, 3 Internal Bypasses Open, All Bays Baffled
Approach Velocity, ft/s
Sweeping Velocity, ft/s
Maximun Targeted Approach Velocity
Minimum Targeted Sweeping Velocity
2.50
2.25
2.00
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00
-0.25
-0.50
-0.75
-1.00
Velocity, ft/s
Bypass 1
Bypass 2
4 deg. bend
Bypass 3
2.9 deg. bend
0
100
200
300
400
500
600
700
800
900
1000
DS
Distance along the screen from downstream end, ft
US

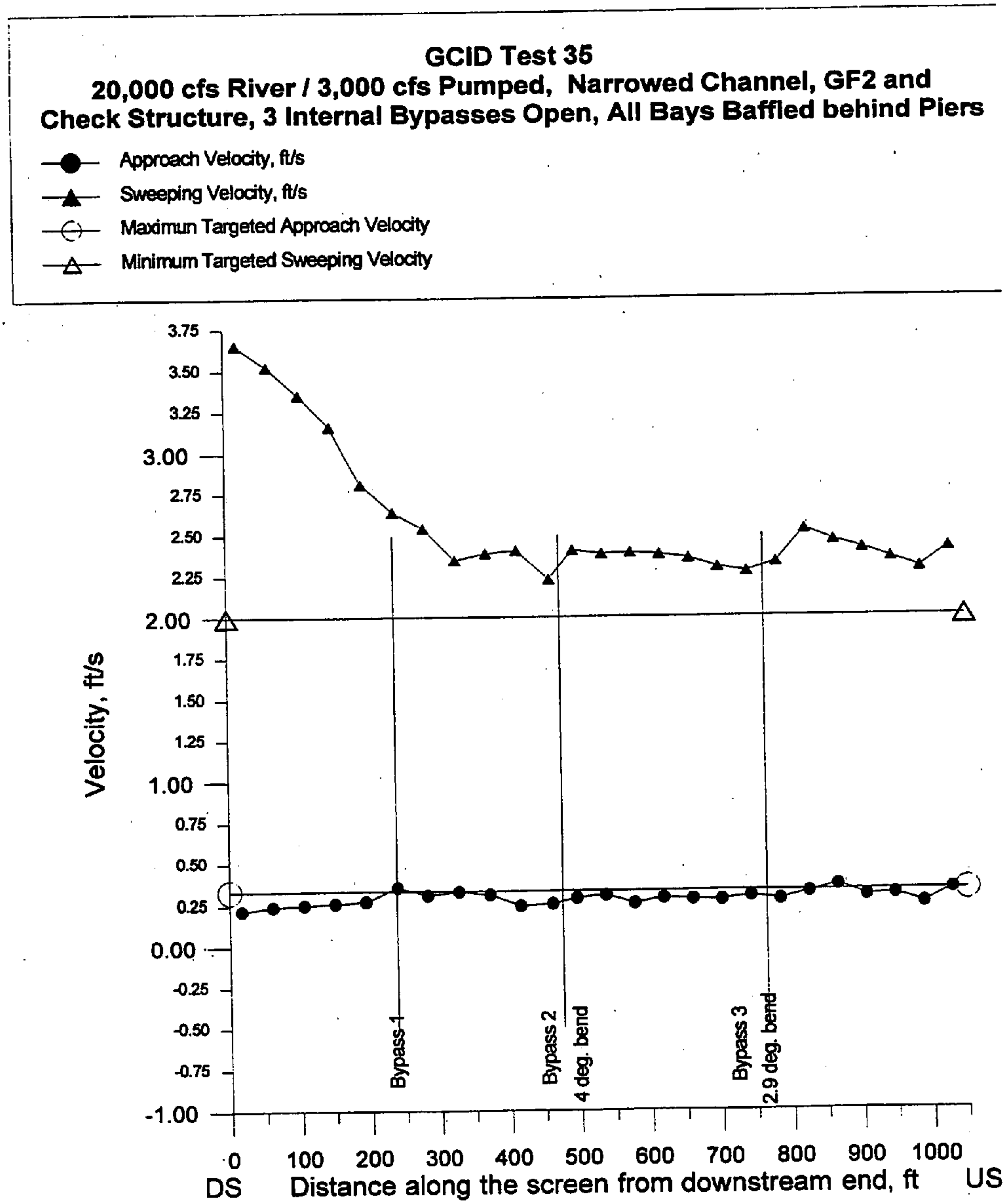
GCID Test 32
20,000 cfs River / 3,000 cfs Pumped, Narrowed Channel, GF2 and Check Structure, 3 Internal Bypasses Open, All Bays Baffled



GCID Test 33
7,000 cfs River / 3,000 cfs Pumped, Narrowed Channel, GF2 and Check Structure, 3 Internal Bypasses Open, All Bays Baffled behind Piers

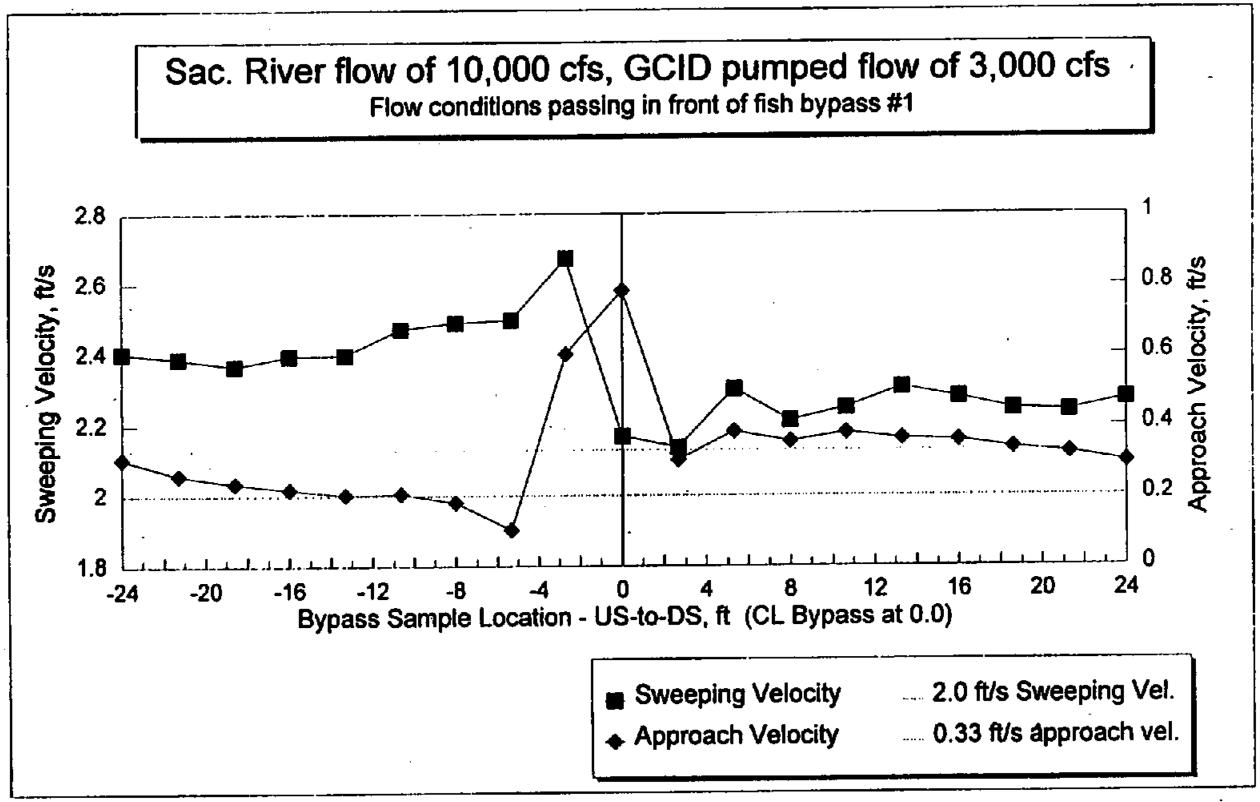



GCID Test 34
10,000 cfs River / 3,000 cfs Pumped, Narrowed Channel, GF2 and Check Structure, 3 Internal Bypasses Open, All Bays Baffled behind Piers
Approach Velocity, ft/s
Sweeping Velocity, ft/s
Maximun Targeted Approach Velocity
Minimum Targeted Sweeping Velocity
Velocity, ft/s
3.50
3.25
3.00
2.75
2.50
2.25
2.00
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00
-0.25
-0.50
-0.75
-1.00
Bypass 1
Bypass 2
4 deg. bend
Bypass 3
2.9 deg. bend
0
100
200
300
400
500
600
700
800
900
1000
DS
Distance along the screen from downstream end, ft
US


GCID Test 35
20,000 cfs River / 3,000 cfs Pumped, Narrowed Channel, GF2 and Check Structure, 3 Internal Bypasses Open, All Bays Baffled behind Piers
Approach Velocity, ft/s
Sweeping Velocity, ft/s
Maximun Targeted Approach Velocity
Minimum Targeted Sweeping Velocity
Velocity, ft/s
3.75
3.50
3.25
3.00
2.75
2.50
2.25
2.00
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00
-0.25
-0.50
-0.75
-1.00
Bypass 1
Bypass 2
4 deg. bend
Bypass 3
2.9 deg. bend
0
100
200
300
400
500
600
700
800
900
1000
DS
Distance along the screen from downstream end, ft
US

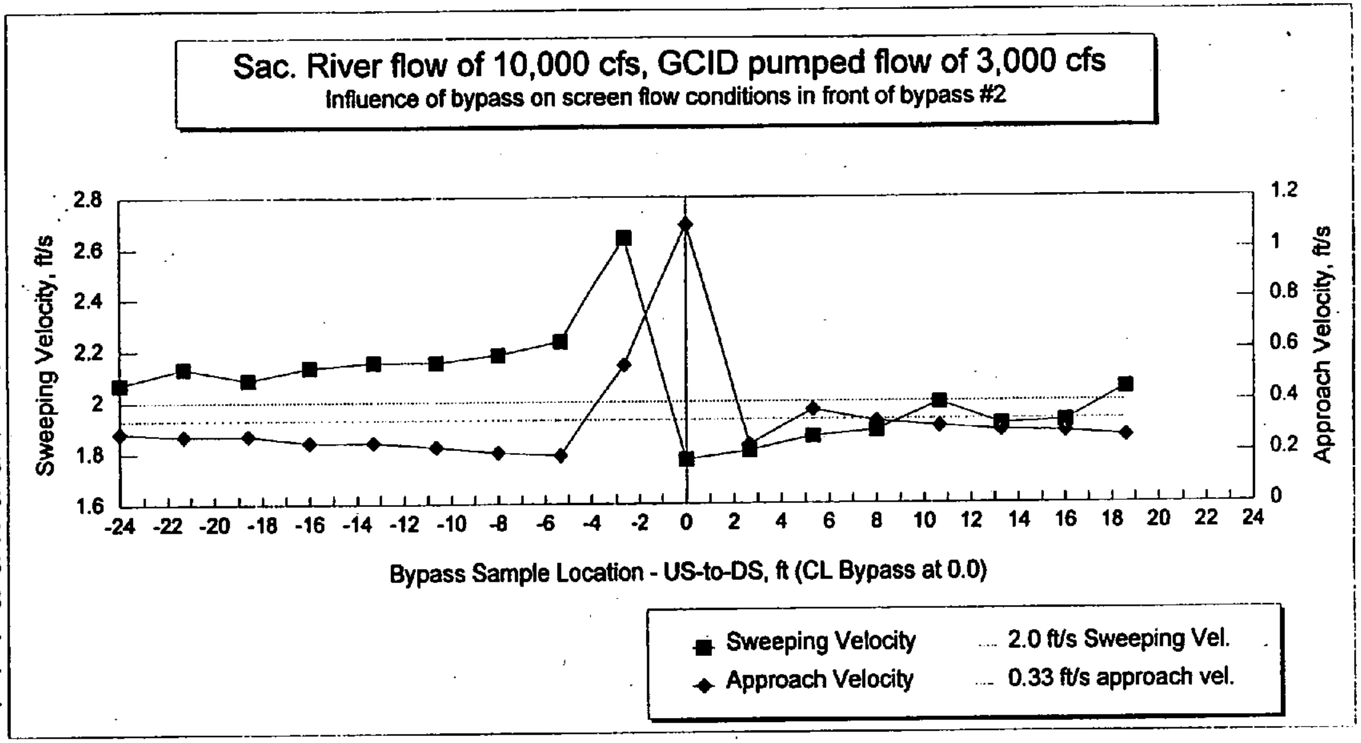
Test 36

Sample loc. US-to-DS ft	Sweeping Velocity ft/s	Approach Velocity ft/s
-24	2.4032	0.3048
-21.3	2.3868	0.258
-18.6	2.3652	0.234
-16	2.3948	0.2164
-13.3	2.3968	0.2016
-10.65	2.472	0.2044
-8	2.4892	0.1792
-5.33	2.4972	0.1012
-2.66	2.6728	0.5992
0	2.1684	0.7808
2.66	2.1368	0.3016
5.33	2.3004	0.3816
8	2.2116	0.3536
10.65	2.248	0.3784
13.3	2.3052	0.362
16	2.2772	0.3576
18.6	2.2452	0.3356
21.3	2.2396	0.322
24	2.2728	0.296



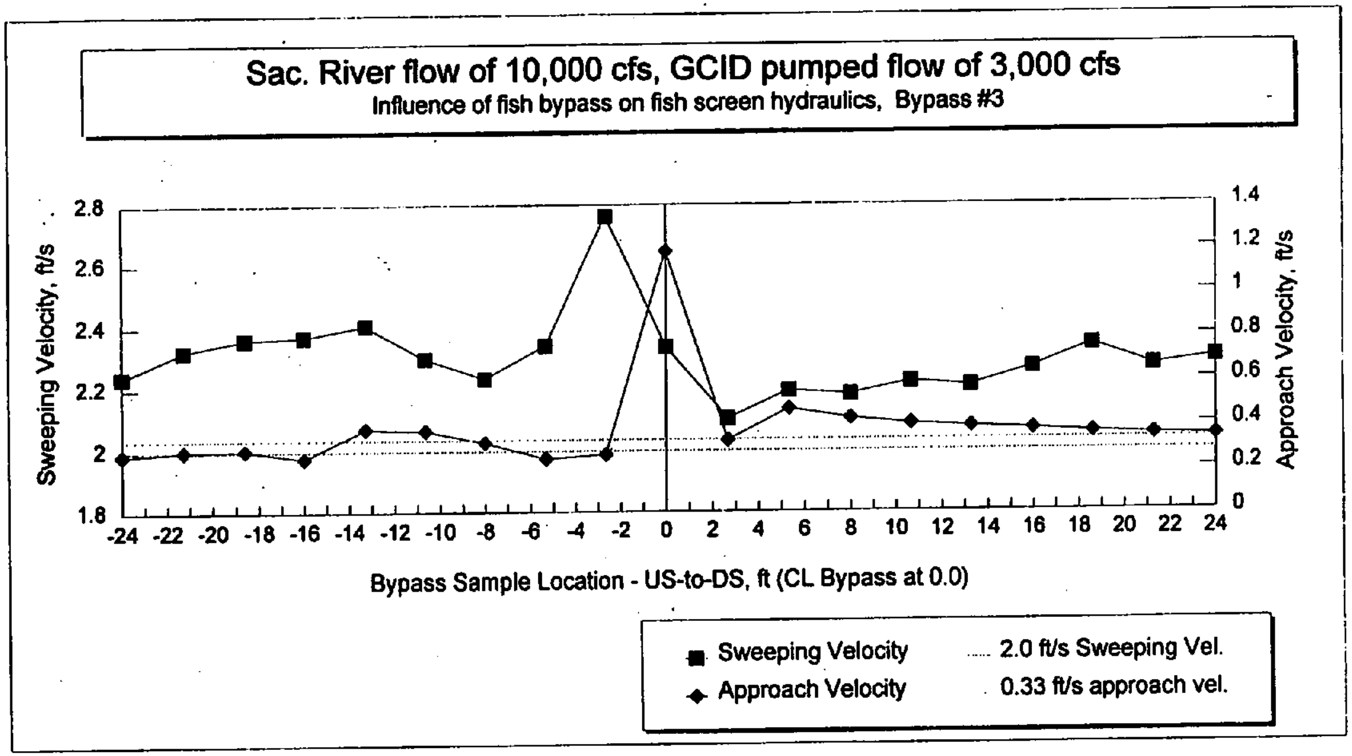
Test 37

Sample loc. US-to-DS ft	Sweeping Velocity ft/s	Approach Velocity ft/s
-24	2.07	0.2792
-21.3	2.1316	0.2664
-18.6	2.0864	0.2684
-16	2.1336	0.2408
-13.3	2.1544	0.2404
-10.65	2.1524	0.2236
-8	2.182	0.2016
-5.33	2.2332	0.1892
-2.66	2.6408	0.5416
0	1.772	1.092
2.66	1.8064	0.2304
5.33	1.862	0.3656
8	1.8852	0.3208
10.65	1.9932	0.2992
13.3	1.9092	0.2836
16	1.92	0.2788
18.6	2.05	0.2604
21.3	1.9952	0.2524
24	2.0052	0.2484



Test 38

Sample loc. US-to-DS ft	Sweeping Velocity ft/s	Approach Velocity ft/s
-24	2.2388	0.2632
-21.3	2.322	0.2788
-18.6	2.3608	0.2836
-16	2.3684	0.2464
-13.3	2.4052	0.3788
-10.65	2.298	0.37
-8	2.2332	0.316
-5.33	2.3396	0.2436
-2.66	2.7604	0.2616
0	2.3352	1.1808
2.66	2.1016	0.3236
5.33	2.1916	0.4648
8	2.1792	0.4216
10.65	2.22	0.3972
13.3	2.206	0.3844
16	2.2636	0.3704
18.6	2.3388	0.3556
21.3	2.2704	0.3448
24	2.2956	0.3372



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13. ABSTRACT *(Maximum 200 words)*

This report covers physical modeling of a 1,050-foot-long positive barrier fish screen. This screen concept was chosen as the final design preferred alternative for the Glenn Colusa Irrigation District (GCID) diversion on the Sacramento River near Hamilton, California. A 1:16 scale model of the diversion intake and proposed screen structure were modeled in the Bureau of Reclamation's Water Resources Research Laboratory in Denver, Colorado.

The study investigated screen hydraulics as a function of approach conditions, screen baffling, and fish bypass design. Measurements of screen approach and sweeping velocity were made to evaluate major design parameters.

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