EVALUATION OF WET-LINE DEPTH-CORRECTION METHODS FOR CABLE-SUSPENDED CURRENT METERS

By William F. Coon and James C. Futrell II

U.S. GEOLOGICAL SURVEY

Water-Resources Investigations Report 85-4329

National Space Technology Laboratories, Mississippi

1986

UNITED STATES DEPARTMENT OF THE INTERIOR

DONALD PAUL HODEL, Secretary

GEOLOGICAL SURVEY

Dallas L. Peck, Director

For additional information write to:

Hydrologic Instrumentation Facility
U.S. Geological Survey, WRD
Building 2101
NSTL, MS 39529

Copies of this report can be purchased from:

Open-File Services Section
Western Distribution Branch
Box 25425, Federal Center
Denver, CO 80225
(Telephone: (303) 236-7476)

CONTENTS

FIGURES

FIGURES (continued)

TABLES

EVALUATION OF WET-LINE DEPTH-CORRECTION METHODS
FOR CABLE-SUSPENDED CURRENT METERS

By William F. Coon and James C. Futrell II

ABSTRACT

Wet-line depth corrections for cable-suspended current meter and weight not perpendicular to the water surface have been evaluated using cable-suspended weights towed by a boat in still water. A fathometer was used to track a Columbus sounding weight and to record its actual depth for several apparent depths, weight sizes, and towed velocities. Cable strumming, tension, and weight veer are noted. Observed depth corrections are compared to wet-line table values used for determining the 0.8-depth position of the sounding weight under these conditions and indicate that questionable differences exist.

INTRODUCTION

A hydrographer, in measuring stream discharge from high bridges or cableways during highflow conditions, frequently encounters situations in which the cable-suspended current meter and sounding weight are dragged downstream. This results in a situation where the length of unreeled cable is greater than the true vertical depth (fig. 1). Corrections to observed depth values can be made by using the procedure outlined by Buchanan and Somers (1969). The included air-correction and wet-line tables provide an adjustment value for application to depth readings, and the theory supporting the air-correction table is acceptable. However, during the development of Kevlar[1] sounding lines at the Hydrologic Instrumentation Facility (HIF) of the U.S. Geological Survey, the accuracy of these wet-line corrections became questionable. This led to testing the "elementary principle of mechanics" (Corbett, 1962) on which the wet-line table is based.

A test plan was developed and executed in which sounding weights were cable-suspended from a boat to various depths and towed at different velocities. A fathometer was used to determine the sounding weight depth changes; then, test results were compared with the depth corrections from the wet-line table applicable to the 0.8-depth position. The study was conducted on Cayuga Lake in upstate New York, because this lake allowed testing at 100-foot depths without the possibility of bottom interference.

---

[1] Use of brand names in this report is for identification purposes only and does not constitute endorsement by the U.S. Geological Survey.

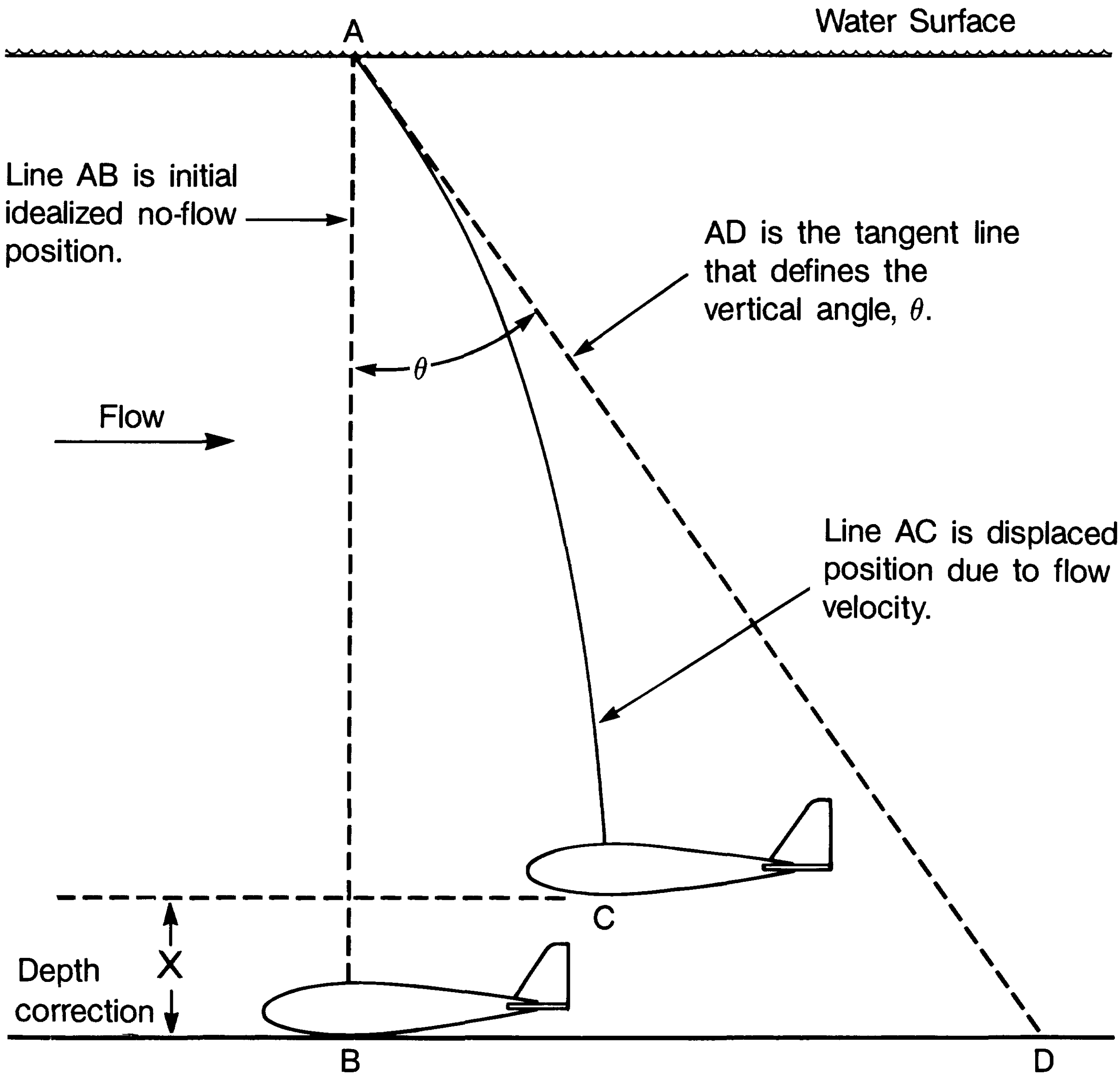


Figure 1.--Displacement of the cable-suspended sounding weight under flow conditions.

EQUIPMENT

A 16-foot boat with a 40-horsepower motor capable of a maximum speed of 20 miles per hour was used for this study. The boat was outfitted with a special boom, which placed the apex of the sounding line about 1 foot in front of the boat, thus preventing the line from coming into contact with the boat's bow during high speeds. Standard Survey 100- and 200-pound sounding weights were suspended on a 0.12-inch-diameter steel sounding line. A standard vertical-angle indicator attached to the end of the boom recorded the sounding line's vertical angles, and a Brunton compass attached to a flat surface of the boat measured the increment of the vertical angle that resulted when the boat deviated from a horizontal position. Both pieces of equipment were set on zero when the boat was stationary and frequently checked during testing. A type-AA current meter was attached to the stern of the boat and positioned approximately 3 feet below the hull. Velocity readings were taken continuously during each run using a current-meter digitizer or headset/stopwatch combination.

A fathometer was used to obtain true depth, and values to the nearest 0.1 foot were taken from the graphic record of the sonar signal. The transducer was handheld over the side of the boat in as near a vertical position as possible while submerged approximately 1 foot (per manufacturer's instructions). The handheld transducer permitted easy horizontal movement in locating the sounding weight and obtaining the true vertical depth. Prior to testing each day, the fathometer's recording stylus was adjusted to account for the 1-foot submergence, and true depth values were then read directly from the chart. A B-56 reel with a 100-foot sounding line was used to lower and raise the weights; the attached depth indicator measured apparent depth values.

Cable or sounding-line tension was measured with a dynamometer, which was calibrated at 5-pound intervals to a maximum 500-pound capacity. After the weight had been lowered to the desired depth, the dynamometer, with cable grippers connected to each end, was attached to the cable between the B-56 reel and the end of the boom. Veer (vertical angle of the sounding line in a direction normal to the flow or, in this case, normal to the direction of the boat's movement) was measured to the nearest degree by a scale specifically designed for this purpose. The scale, attached to the horizontal arm of the vertical-angle indicator, was calibrated in 5-degree increments on either side of a zero line that corresponded to the sounding line hanging vertically from the stationary boat. Strum (measure of the amount of vibration in a taut sounding line being subjected to the force of fast-moving water) was measured approximately 1 foot below the sheave of the boom with a caliper rule marked in eighths of an inch. Three to four measurements were made, and an average measurement was recorded.

TESTING PROCEDURE

Testing was contingent upon weather and lake conditions, which were generally good during the 7 days of actual testing. The water surface was either calm or slightly choppy and when conditions worsened, testing was discontinued for the day. Testing required two individuals: one piloted the boat, operated the fathometer, and made velocity measurements; the other measured vertical angles, cable strum, and weight veer. At least four test runs were made using different velocities at apparent depths of 5, 10, 20, 40, 70, and 97 feet with the 100-pound weight, and at 95 feet with the 200-pound weight. Therefore, each test included a low-velocity run, usually around 5 feet per second, two intermediate velocity runs, and a maximum velocity run. The conditions controlling the maximum velocity run were the speed of the boat and the ability of the sonar to track the sounding weight, which had to be directly under the transducer.

Prior to the beginning of each test run, the following preparations were made:

1. The vertical-angle indicator and Brunton compass were set on zero.

2. The depth indicator was zeroed when the top of the sounding weight was at the water surface. The sonar signal rebounded from the top of the weight.

3. The weight was lowered to the desired apparent depth.

4. The dynamometer was attached to the cable.

5. The stationary or low-speed measurement of true depth was taken with the fathometer.

One of the following methods was used for tracking the sounding weights:

1. Maintaining a desired velocity while moving the transducer along the boat's side until located over the weight.

2. Holding the transducer stationary at one point on the side of the boat while gradually increasing the boat's speed until the weight moved back to a position beneath the transducer.

In either case, as soon as a true depth value was obtained, the velocity was held constant while cable tension, line and boat angles, veer, and strum were measured. This measurement took from 3 to 4 minutes and velocity readings were taken continuously, providing an average velocity for each run. Two readings were noted for cable tension: the average tension, which was read to the nearest pound; and the maximum tension, which was usually read to the nearest 5 pounds. The test run was terminated as soon as the other measurements for line and boat angle, veer, and strum were recorded, and the last velocity reading was completed.

DATA COLLECTED

The data collected are presented in tables 1 and 2. The average velocity is calculated from two-to-four velocity readings taken during each run. The variation in velocity for any given run averages ±0.14 foot per second. This value is calculated by subtracting the lowest velocity reading from the highest velocity reading for each run (variation) and dividing the sum of these values by the number of test runs. Significant variation (greater than 0.50 foot per second) is noted for the following runs:

Weight size (pound)	Apparent depth (feet)	Average velocity (feet per second)	Variation in velocity readings (feet per second)
100	5	15.00	0.71
100	5	19.10	0.96
100	10	17.70	1.04
100	20	16.92	0.92
100	40	13.24	1.18
200	5	16.22	1.70
200	5	15.42	1.08
200	10	12.34	1.86
200	10	15.68	1.30
200	20	13.53	0.57

These velocity variations may account for some discrepancies found in the plotting of data for these runs, since a large fluctuation in velocity could reduce the validity of an instantaneous measurement, for example, line or boat angle.

Table 1. Data collected during 1982 cable-suspension tests using a 100-pound Columbus weight

Apparent depth (feet)	Date	Average velocity (ft/s)	True depth (feet)	Change in depth[1] (feet)	Cable tension avg (pounds)	Cable tension max (pounds)	Line angle (deg)	Boat angle (deg)	Vertical angle (deg)	Veer (deg)	Strum (inch)
5.0	9/9	0.0	5.5	--	--	--	--	--	--	--	--
		5.19	5.5	0.0	93	100	0	0	0.0	0	0.20
		9.76	5.3	-0.2[a]	100	120	5	0	5.0	0	0.31
		15.00	4.3	-1.2[a]	95	115	9	3.5	5.5	2	0.14
	9/13	0.0	5.0	--	--	--	--	--	--	--	--
		19.10	4.3	-0.7[a]	102	125	25	5.0	20.0	9	0.12[b]
10.0	9/9	0.0	10.3	--	--	--	--	--	--	--	--
		4.73	10.3	0.0	90	120	0	0	0	0	0.25
		9.61	10.2	-0.1	97	135	10	0	10.0	1	0.28
		14.53	9.4	-0.9[a]	90	115	15	3.5	11.5	2	0.22
	9/13	0.0	--	--	--	--	--	--	--	--	--
		17.70	--	--	108	140	20	5.0	15.0	6	0.20
	9/30	0.0	10.1	--	--	--	--	--	--	--	--
		7.52	10.0	-0.1	94	110	14	3.0	11.0	1	0.25
20.0	9/9	0.0	20.2	--	--	--	--	--	--	--	--
		4.88	20.2	0.0	93	105	6	0	6.0	0	0.28
		9.76	20.0	-0.2	110	140	20	0	20.0	0	0.28
		14.76	18.2	-2.0	95	120	30	3.5	26.5	3	0.31
	9/13	0.0	20.0	--	--	--	--	--	--	--	--
		16.92	17.6	-2.4	102	125	36	5.0	31.0	5	0.22

Table 1. Data collected during 1982 cable-suspension tests using a 100-pound Columbus weight (continued)

Apparent depth (feet)	Date	Average velocity (ft/s)	True depth (feet)	Change in depth[1] (feet)	Cable tension avg (pounds)	Cable tension max (pounds)	Line angle (deg)	Boat angle (deg)	Vertical angle (deg)	Veer (deg)	Strum (inch)
40.0	9/9	0.0	40.2	--	--	--	--	--	--	--	--
		5.44	40.2	0.0	93	105	14	0	14.0	0	0.28
		7.89	38.2	-2.0	112	130	25	0	25.0	0	0.31
		9.59	37.2	-3.0	120	180	33	0	33.0	0	0.30
		10.12	36.2	-4.0	118	150	34	2.0	32.0	0	0.28
		13.24	--	--	95	125	52	3.5	48.5	0	0.30
70.0	9/13	0.0	70.3	--	--	--	--	--	--	--	--
		5.00	68.1	-2.2	102	120	23	0	23.0	0	0.36
		6.56	67.3	-3.0	105	130	29	0	29.0	0	0.38
		8.26	64.3	-5.5	104	130	39	1.0	38.0	0	0.33
		9.46	60.9	-9.4	103	125	48	1.5	46.5	0	0.28
97.0	9/9	0.0	97.5	--	--	--	--	--	--	--	--
		5.78	93.3	4.2	95	115	35	0	35.0	0	0.34
		8.66	85.2	-12.3	105	160	54	1.5	52.5	0	0.31
	9/13	0.0	97.8	--	--	--	--	--	--	--	--
		7.55	90.4	-7.4	98	115	44	1.0	43.0	0	0.34
		8.20	88.2	-9.6	95	110	46	1.5	44.5	0	0.33

[1]Depth correction.

[a]Questionable value from comparison with air-correction table (Buchanan and Somers, 1969).

[b]No strum measurable for 0.12-inch-diameter sounding line.

Table 2. Data collected during 1982 cable-suspension tests using a 200-pound Columbus weight

Apparent depth (feet)	Date	Average velocity (ft/s)	True depth (feet)	Change in depth[1] (feet)	Cable tension avg (pounds)	Cable tension max (pounds)	Line angle (deg)	Boat angle (deg)	Vertical angle (deg)	Veer (deg)	Strum (inch)
5.0	9/10	0.0	5.3	--	--	--	--	--	--	--	--
		5.26	5.3	0.0	173	180	0	-1.0	1.0	0	0.17
		8.14	--	--	174	185	1	-1.0	2.0	0	0.30
		11.50	--	--	174	190	3	1.5	1.5	0	0.26
		16.22	--	--	175	195	5	3.5	1.5	0	0.20
	9/30	0.0	5.0	--	--	--	--	--	--	--	--
		5.08	5.0	0.0	179	183	2	-1.0	3.0	0	0.17
		9.46	5.0	0.0	178	188	3	-1.0	4.0	0	0.20
		11.33	4.9	-0.1[a]	178	190	4	1.0	3.0	0	0.22
		15.42	4.7	-0.3[a]	174	190	5	3.5	1.5	0	0.16
10.0	9/10	0.0	10.4	--	--	--	--	--	--	--	--
		5.03	10.4	0.0	173	180	2	-1.0	3.0	0	0.34
		8.20	--	--	176	190	4	-1.0	5.0	0	0.36
		12.34	9.6	-0.8[a]	176	200	9	3.0	6.0	0	0.20
		15.63	9.3	-1.1[a]	177	210	10	3.5	6.5	0	0.25
	9/30	0.0	10.2	--	--	--	--	--	--	--	--
		8.60	10.2	0.0	176	190	5	-1.0	6.0	0	0.25
		0.0	10.0	--	--	--	--	--	--	--	--
		13.59	8.9	-1.1[a]	177	190	9	3.0	6.0	0	0.20
20.0	9/10	0.0	20.7	--	--	--	--	--	--	--	--
		5.28	20.7	0.0	175	190	3	-1.0	4.0	0	0.31
		6.86	20.6	-0.1	182	187	5	-1.0	6.0	0	0.38
		9.67	19.5	-1.2[a]	181	210	16	3.0	13.0	0	0.26
		13.53	19.3	-1.4[a]	182	210	17	3.5	13.5	0	0.20

Table 2. Data collected during 1982 cable-suspension tests using a 200-pound Columbus weight (continued)

Apparent depth (feet)	Date	Average velocity (ft/s)	True depth (feet)	Change in depth[1] (feet)	Cable tension avg (pounds)	Cable tension max (pounds)	Line angle (deg)	Boat angle (deg)	Vertical angle (deg)	Veer (deg)	Strum (inch)
40.0	9/10	0.0	40.2	--	--	--	--	--	--	--	--
		5.01	40.0	-0.2	180	188	7	-1.0	8.0	0	0.34
		6.58	--	--	187	205	11	-1.0	12.0	0	0.41
		9.87	39.6	-0.6	200	235	20	0.0	20.0	0	0.38
		13.40	36.6	-3.6	205	240	31	3.5	27.5	0	0.38
	9/30	0.0	40.0	--	--	--	--	--	--	--	--
		8.07	39.8	-0.2	178	195	16	-1.0	17.0	0	0.36
70.0	9/10	0.0	71.4	--	--	--	--	--	--	--	--
		5.09	70.7	-0.7	185	197	12	-1.0	13.0	0	0.31
		7.61	69.3	-2.1	190	225	24	-1.0	25.0	0	0.39
		10.32	67.0	-4.4	193	235	38	1.0	37.0	0	0.41
		12.53	61.5	-9.9	195	230	45	3.5	41.5	0	0.38
95.0	9/13	0.0	95.0	--	--	--	--	--	--	--	--
		3.86	94.9	-0.1	187	210	9	-1.0	10.0	0	0.26
		4.94	94.3	-0.7	185	194	15	-1.0	16.0	0	0.28
		6.90	92.1	-2.9	188	240	28	-1.0	29.0	0	0.41
		9.39	85.1	-9.9	192	230	42	1.0	41.0	0	0.34

[1] Depth correction.

[a] Questionable value from comparison with air-correction table (Buchanan and Somers, 1969).

True depth values were read from the fathometer's graphic record after any necessary minor corrections were made. Sometimes the recording stylus in veering 0.1 to 0.2 foot from the calibration line created difficulties in reading the graphic record and, consequently, in determining the true depth value. When faint or irregular marks (occasional high-velocity occurrences) and "painting" (shallow-depth occurrences) prevented a reliable determination of sounding-weight depth, an echo, which was usually clearer and recorded at multiples of true depth, was used to determine the true-depth value. True depth was then calculated by dividing the echo depth by 2 (or 3 as in the 100-pound run at an apparent depth of 5 feet with a velocity of 15 feet per second). Frequently, a pair of marks (approximately 1 foot apart) were recorded and interpreted to indicate the top of the weight and the cable connector above it.

The change in depth or depth correction is the difference between the initial true-depth measurement (taken while the boat was stationary or during its first low-speed run) and the true depth at indicated velocities (fig. 1). If parts of a test were conducted on different days for identical setups (that is, weight size and apparent depth) the initial true depth is different, as noted in tables 1 and 2. The validity of the calculated depth correction was checked by comparing the measured values with the corrections listed in the air-correction table (Buchanan and Somers, 1969).

Because these table values represent the difference between the vertical and inclined lengths of the sounding line for given vertical angles (with no adjustment for the downward curving of the line in flowing water (fig. 1)), it is assumed that the values represent the upper limits of the measured depth corrections. Any depth correction that exceeds these limits is mathematically questionable and is noted in tables 1 and 2.

The vertical angle could not be taken directly from the vertical-angle indicator, since the boat at fast speed raised its bow out of the water and a greater angle was recorded than would have been registered if the boat had remained in a horizontal position. This error, measured by the Brunton compass, was determined to be equal to the horizontal angle of the boat. When testing with the 200-pound weight at low velocities, negative angles were recorded for the boat angle because of the downward tipping of the boat while moving. The actual vertical angle was calculated by subtracting the boat angle from the line angle. Veer angle is an error in the lateral, longitudinal, and vertical positioning of a current meter when cable suspended. Veer angle was measured during this study and is recorded in tables 1 and 2, but no correction for veer was attempted.

During this study, veer was always to the right. Since veer was noted only with the 100-pound weight, its occurrence was assumed to be primarily a function of the sounding weight. The values for strum were not adjusted for the diameter of the sounding line. Therefore, a strum value of 0.12 inch indicates that no strum was measurable.

The limits of accuracy for each measured variable are listed in table 3. These limits are based on the degree of calibration of each piece of measuring equipment and the ease or difficulty with which each parameter was measured. The degree of accuracy for true depth is based on the graphic increments of the fathometer. However, this range may be much greater for the high-velocity runs due to the difficulty in maintaining the transducer at a 1-foot depth. The accuracy of the depth correction is the sum of the accuracy limits for apparent depth and true depth. Likewise, the vertical angle is based on the accuracy limits of the line and boat angles.

Table 3. Measurement accuracy

Measurement	Accuracy
Velocity (variation for a given run)	Avg. ±0.14 foot per second (max. of 1.86 feet per second)
Apparent depth	±0.1 foot
True depth	±0.1 foot
Change in depth or depth correction	±0.2 foot
Cable tension - average - maximum	±2.0 pounds ±5.0 pounds
Line angle	±1.0 degree
Boat angle	±0.5 degree
Vertical angle	±1.5 degrees
Veer	±1.0 degree
Strum	+0.12 inch

DATA ANALYSIS

The observed depth corrections are plotted against vertical angles for each apparent depth and sounding-weight size, and the corresponding wet-line curve is included for comparison (see figures 2-7). Figures 8 and 9 show the same information, but with the curves grouped together by weight size in order to depict the change in depth correction with an increase in depth. Figures 4, 5, and 7 indicate some disparity between the measured depth correction curves and the wet-line table curve, as highlighted in table 4. They also show differences between the measured corrections based on weight size, which is an unexpected result.

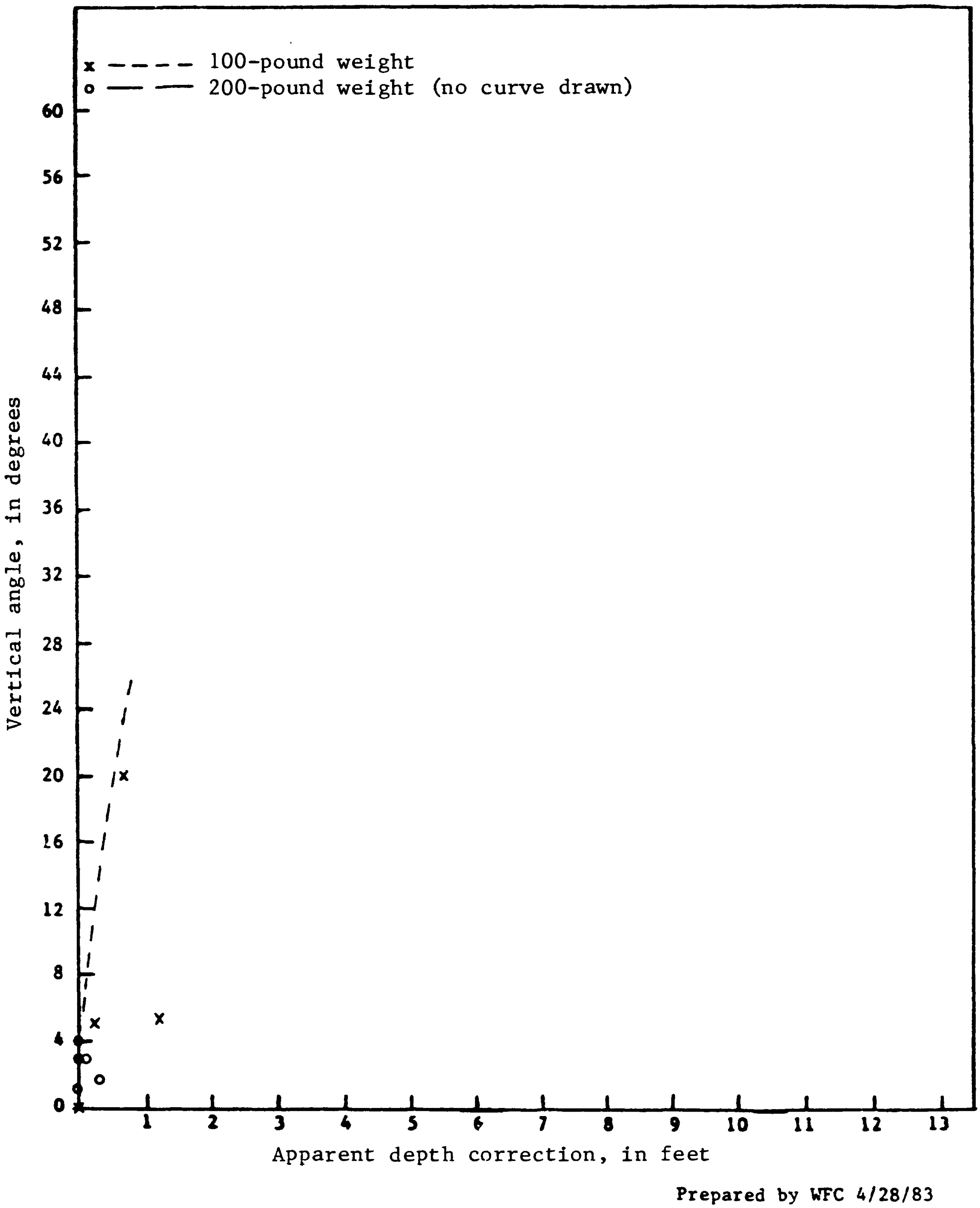
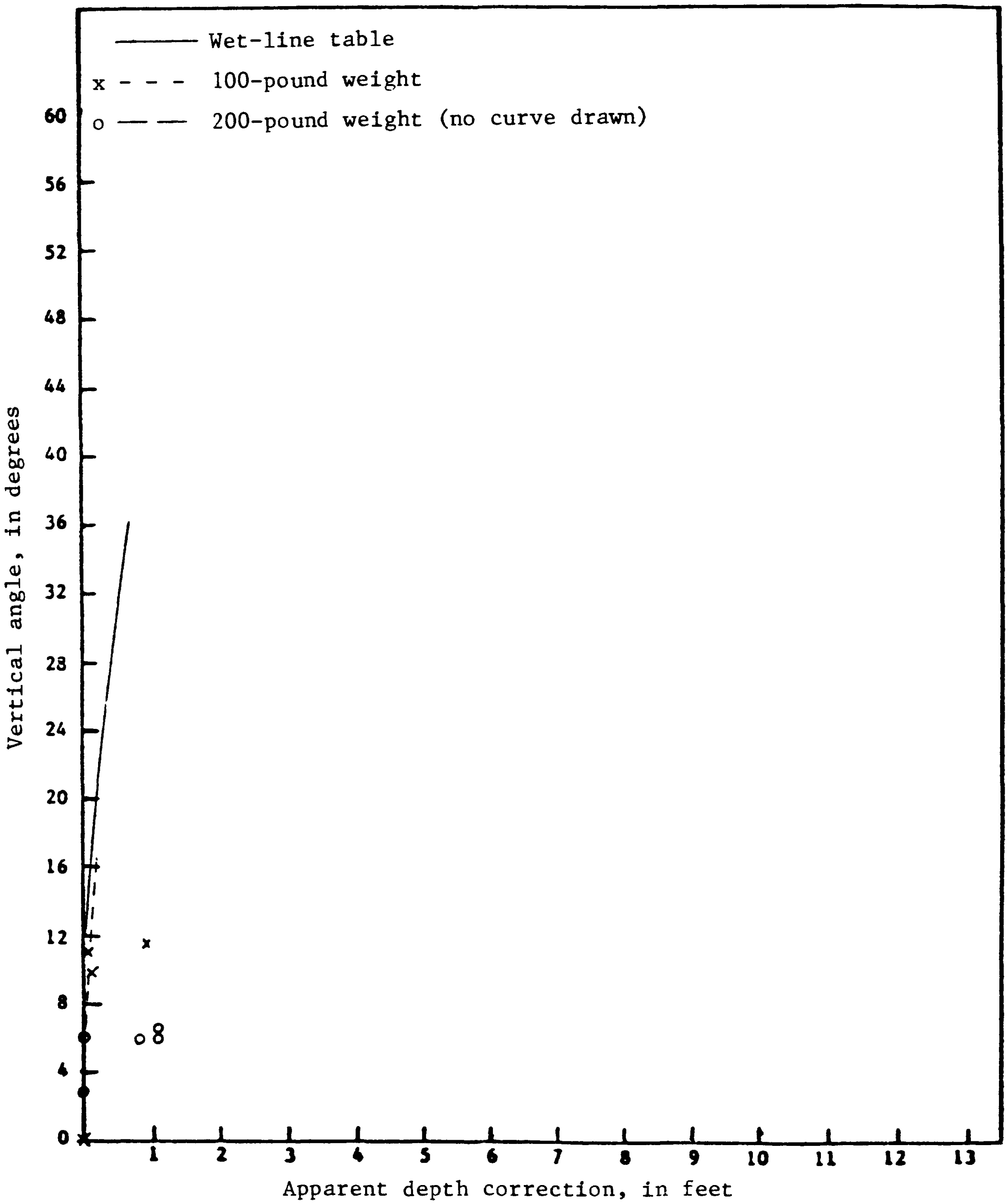
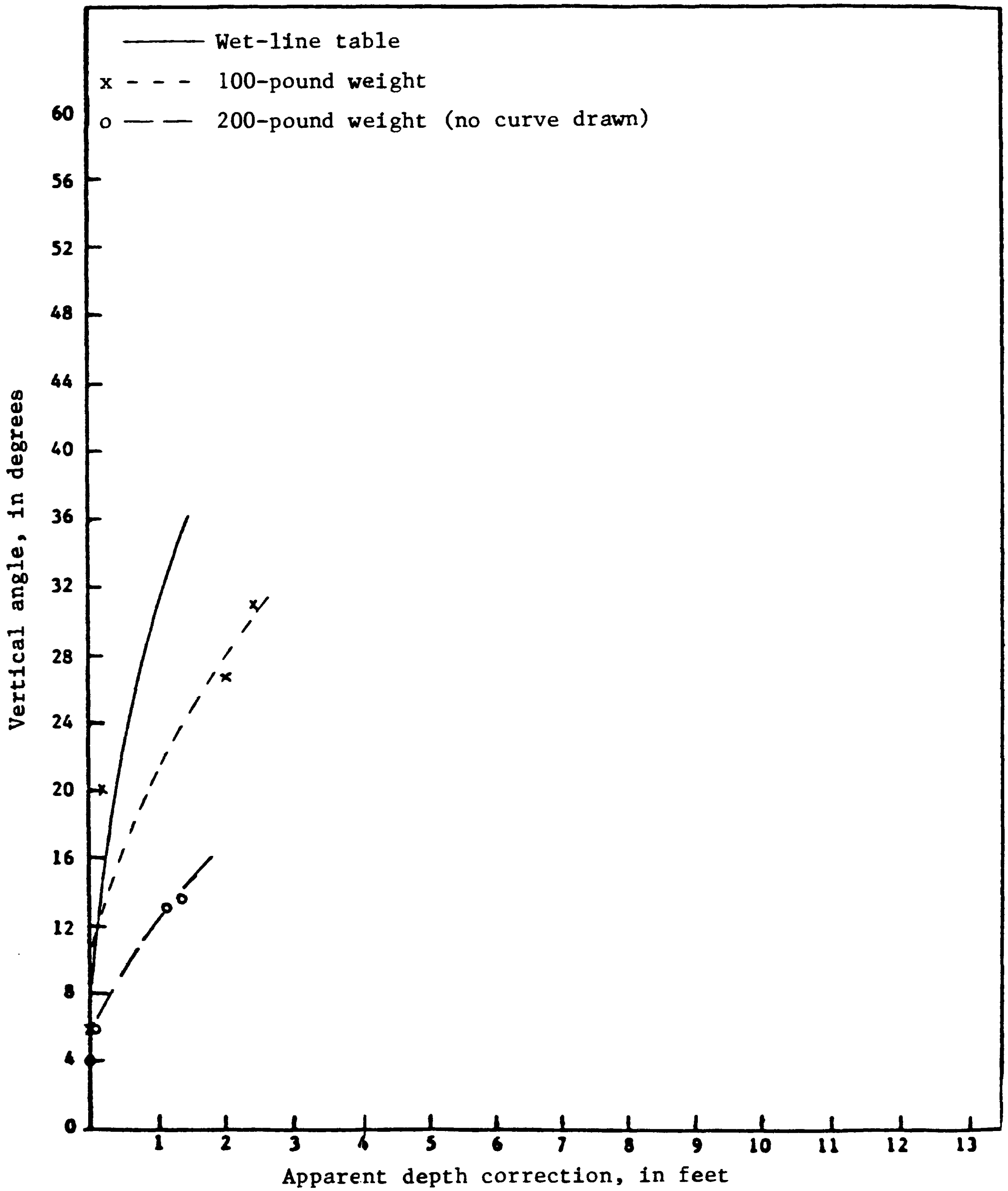


Figure 2. Depth-correction comparison--apparent depth 5 feet.



Prepared by WFC 4/28/83

Figure 3.--Depth-correction comparison--apparent depth 10 feet.



Prepared by WFC 4/28/83

Figure 4.--Depth-correction comparison--apparent depth 20 feet.

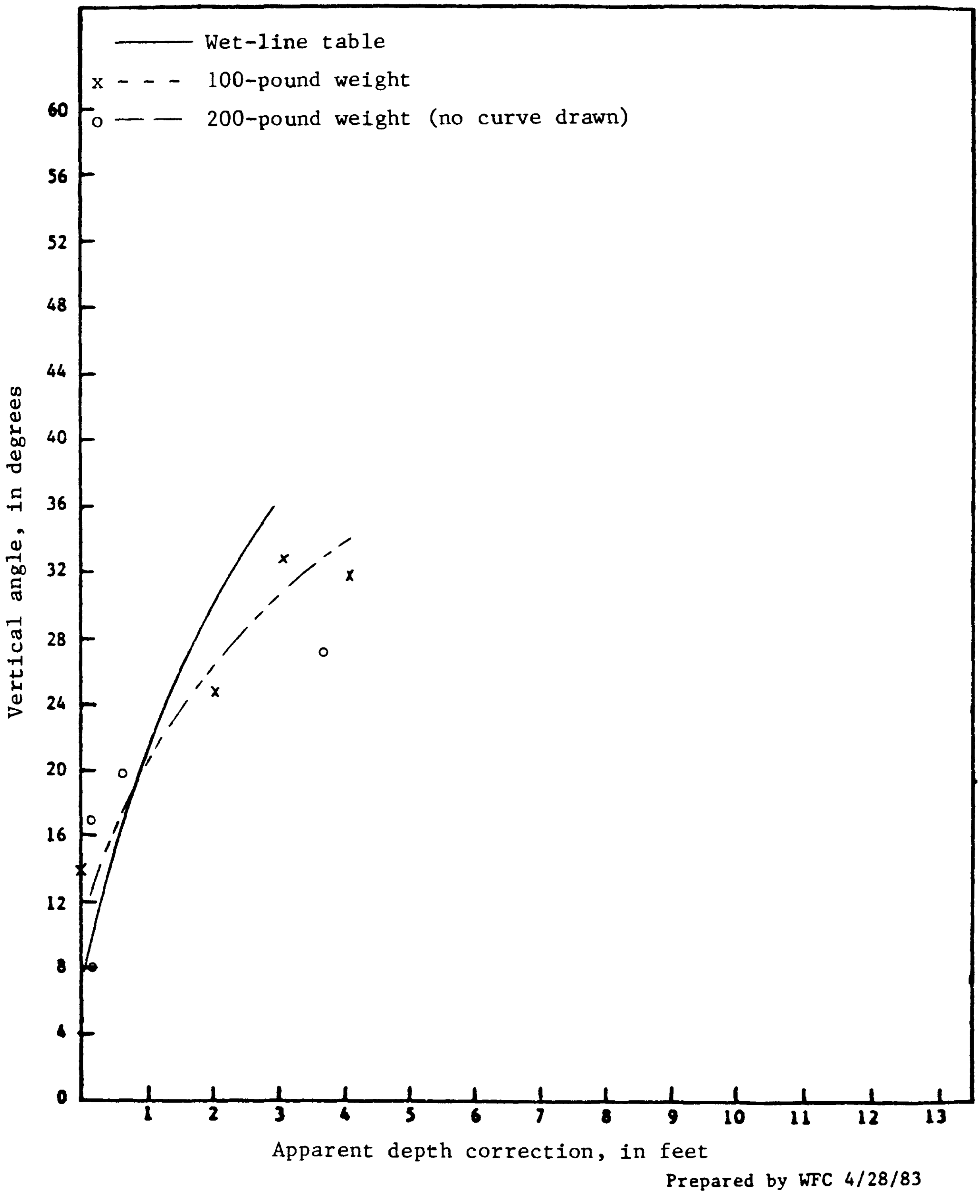


Figure 5.--Depth-correction comparison--apparent depth 40 feet.

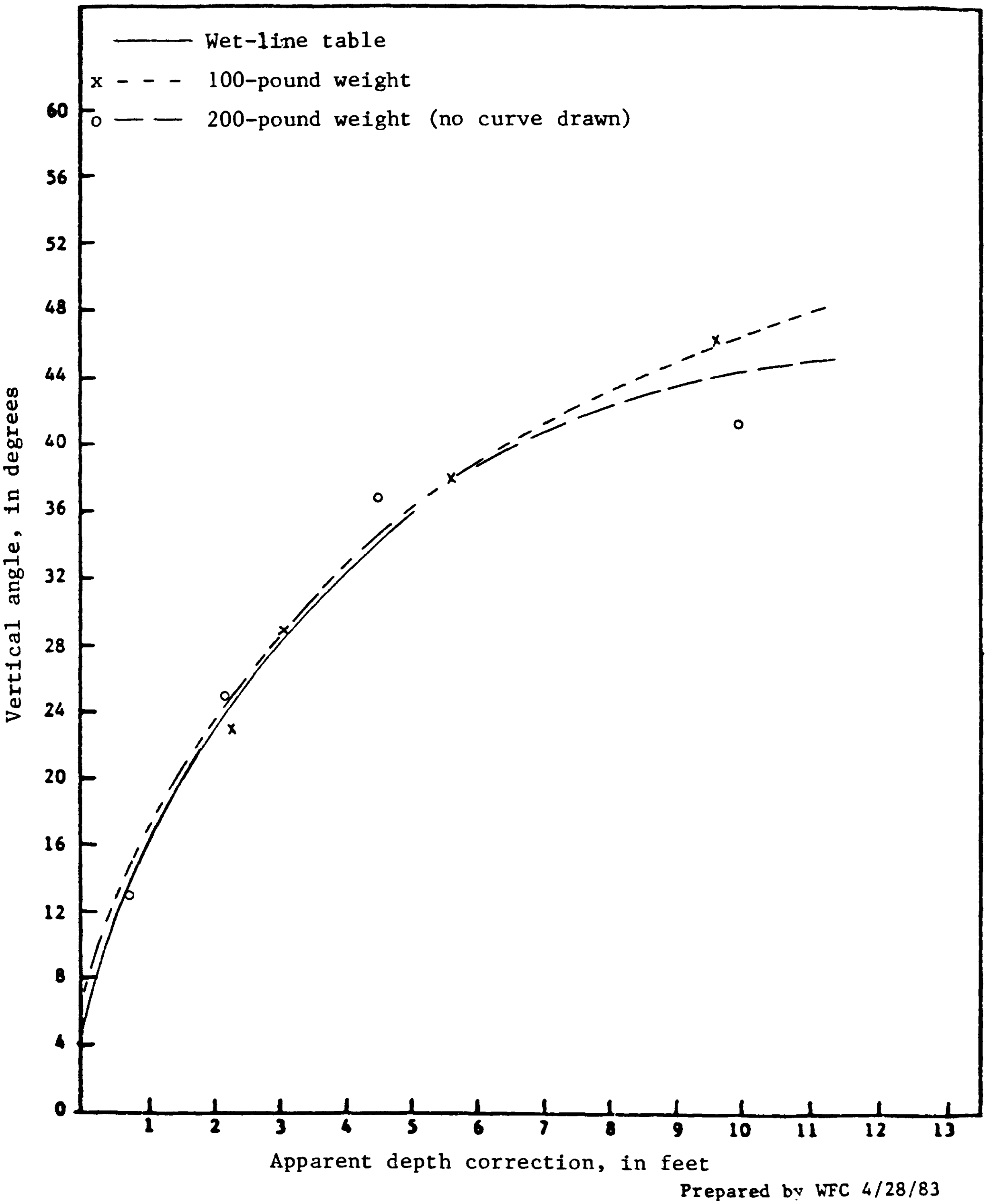


Figure 6.--Depth-correction comparison--apparent depth 70 feet.

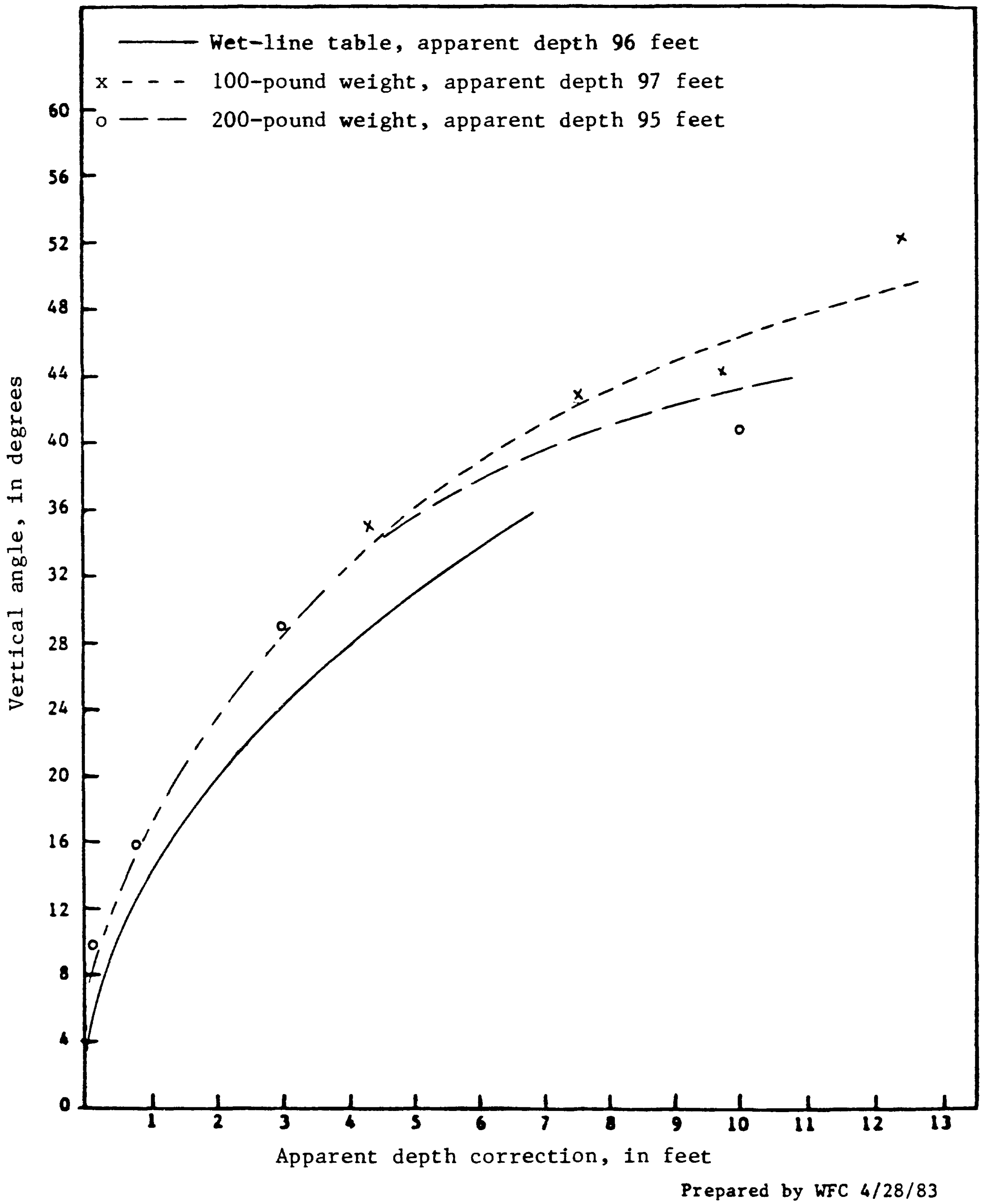


Figure 7.--Depth-correction comparison--apparent depth 96 feet.

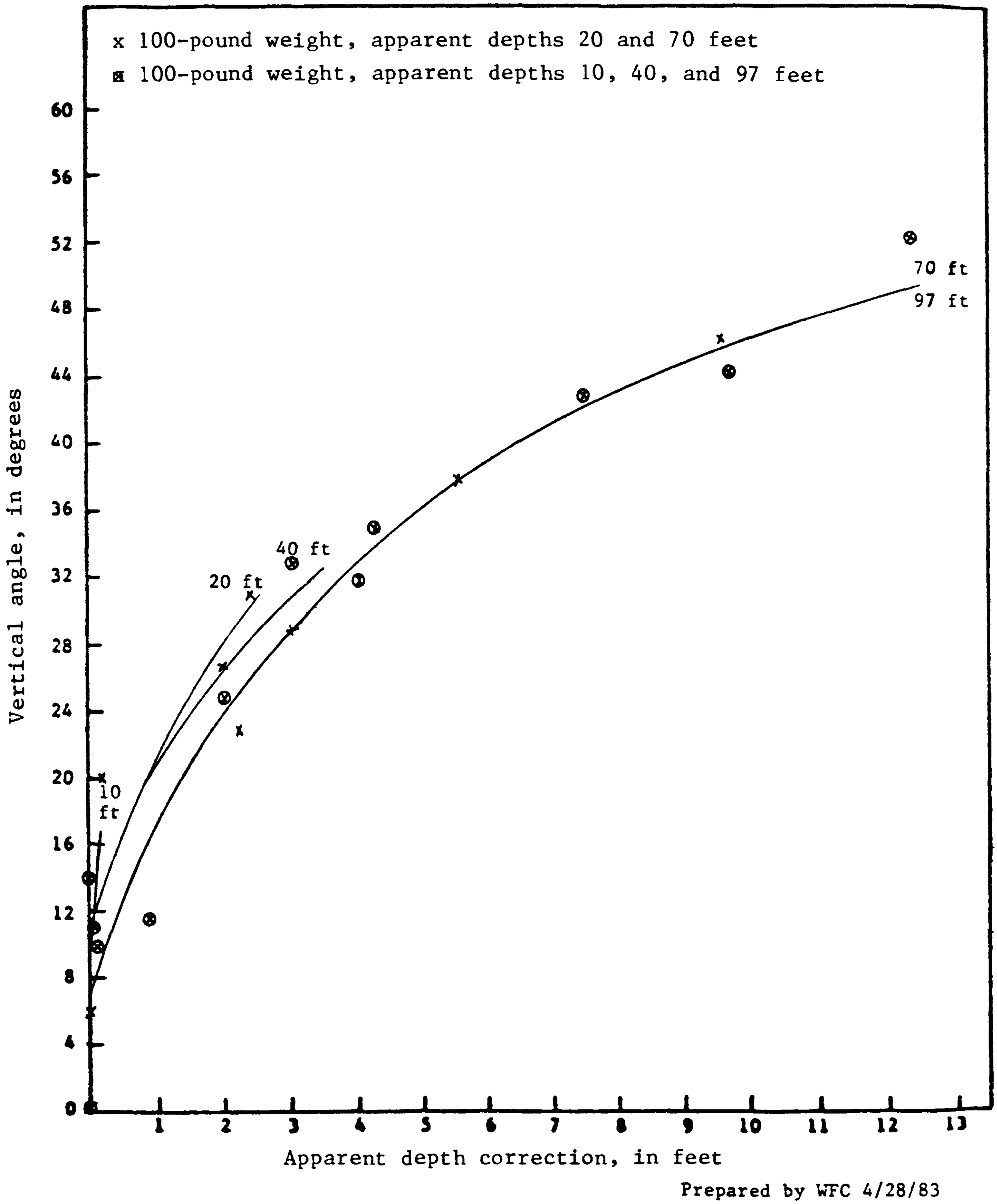
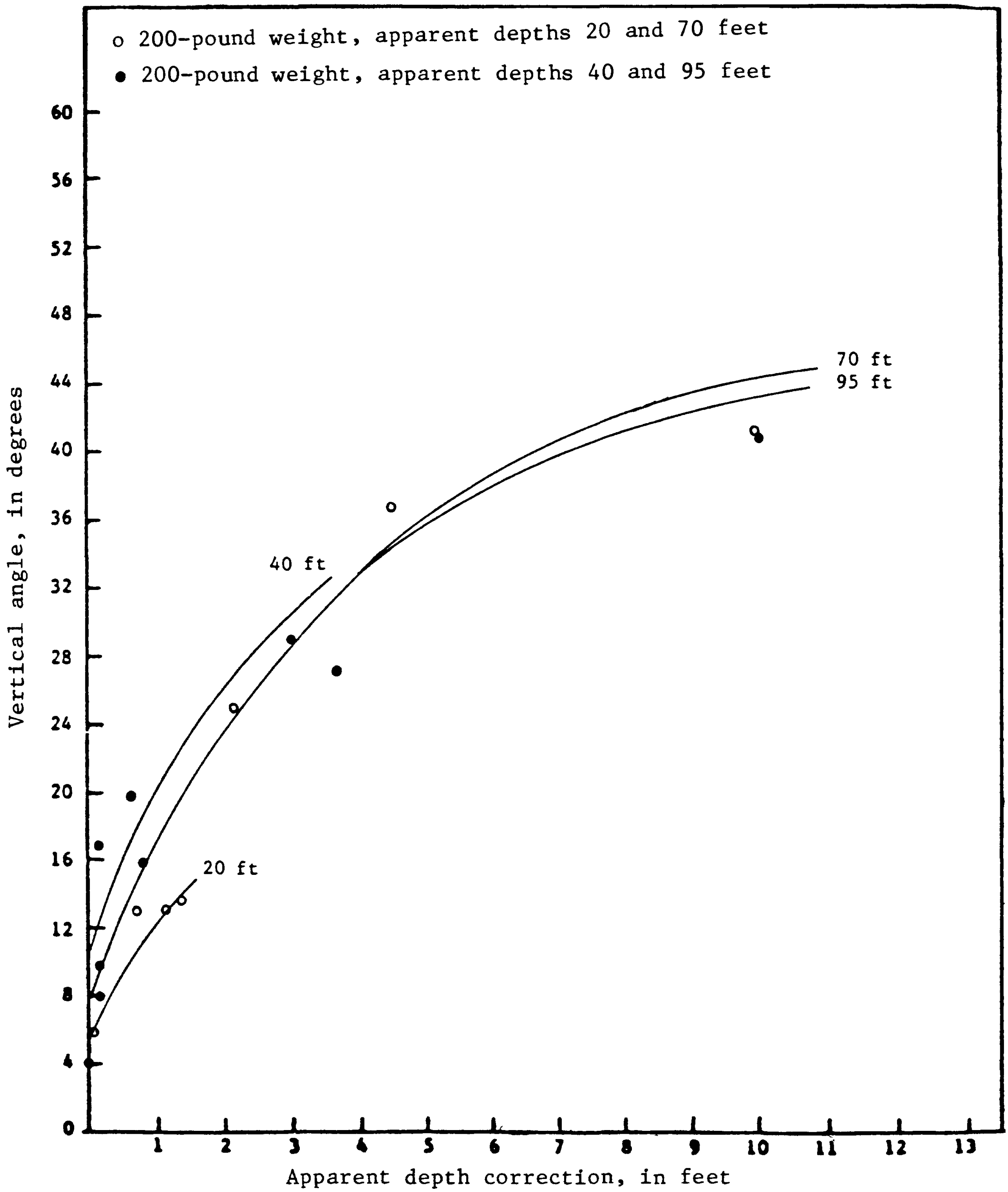


Figure 8.--Depth-correction comparison (100-pound Columbus weight used).



Prepared by WFC 4/28/83

Figure 9.--Depth-correction comparison (200-pound Columbus weight used).

Table 4. Comparison of depth-correction data using 100- and 200-pound weights

Weight size (pound)	Apparent depth (feet)	Vertical angle (degrees)	Wet-line table correction (feet)	Measured depth correction (feet)	Difference (feet)
100	10.0	10.0	0.0	0.1	-0.1
	--	11.0	0.1	0.1	0.0
	20.0	6.0	0.0	0.0	0.0
	--	20.0	0.4	0.2	+0.2
	--	26.5	0.7	2.0	-1.3
	--	31.0	1.0	2.4	-1.4
	40.0	14.0	0.4	0.0	+0.4
	--	25.0	1.3	2.0	-0.7
	--	32.0	2.2	4.0	-1.8
	--	33.0	2.3	3.0	-0.7
	70.0	23.0	1.9	2.2	-0.3
	--	29.0	3.1	3.0	+0.1
	--	38.0	4.9[a]	5.5	--
	--	46.5	4.9[a]	9.4	--
	97.0	35.0	6.4	4.2	+2.2
	--	43.0	6.8[a]	7.4	--
	--	44.5	6.8[a]	9.6	--
	--	52.5	6.8[a]	12.3	--
200	10.0	3.0	0.0	0.0	0.0
	--	6.0	0.0	0.0	0.0
	20.0	4.0	0.0	0.0	0.0
	--	6.0	0.0	0.1	-0.1
	40.0	8.0	0.1	0.2	-0.1
	--	17.0	0.6	0.2	+0.4
	--	20.0	0.8	0.6	+0.2
	--	27.5	1.6	3.6	-2.0
	70.0	13.0	0.6	0.7	-0.1
	--	25.0	2.3	2.1	+0.2
	--	37.0	4.9[a]	4.4	--
	--	41.5	4.9[a]	9.9	--

Table 4. Comparison of depth-correction data using 100- and 200-pound weights (continued)

Weight size (pound)	Apparent depth (feet)	Vertical angle (degrees)	Wet-line table correction (feet)	Measured depth correction (feet)	Difference (feet)
	95.0	10.0	0.4	0.1	+0.3
	--	16.0	1.2	0.7	+0.5
	--	29.0	4.2	2.9	+1.3
	--	41.0	6.6[a]	9.9	--

[a]Exceeds upper limit of wet-line table.

In an attempt to identify any other significant relationship existing between the data, the depth corrections were plotted against average cable tension and velocity. Since the cable tension curves do not show any logical trend, they are not included in this report. The velocity versus depth-correction curves, however, do indicate a reasonable and consistent relationship. The plots of these parameters are shown for each apparent depth in figures 10-15 and are grouped together by weight size in figures 16 and 17. These figures verify the known relationship of a smaller vertical angle resulting if a larger weight is used. The difference in depth correction based on weight size is also apparent from these graphs.

Although not used in this analysis for correcting data, cable tension, veer, and strum were measured and supplied in this report as indicators of potential sources of errors. These measurements are available for development of a formula that would mathematically define the relationship between depth correction and any other variable. This enables the development of new wet-line correction tables if desired.

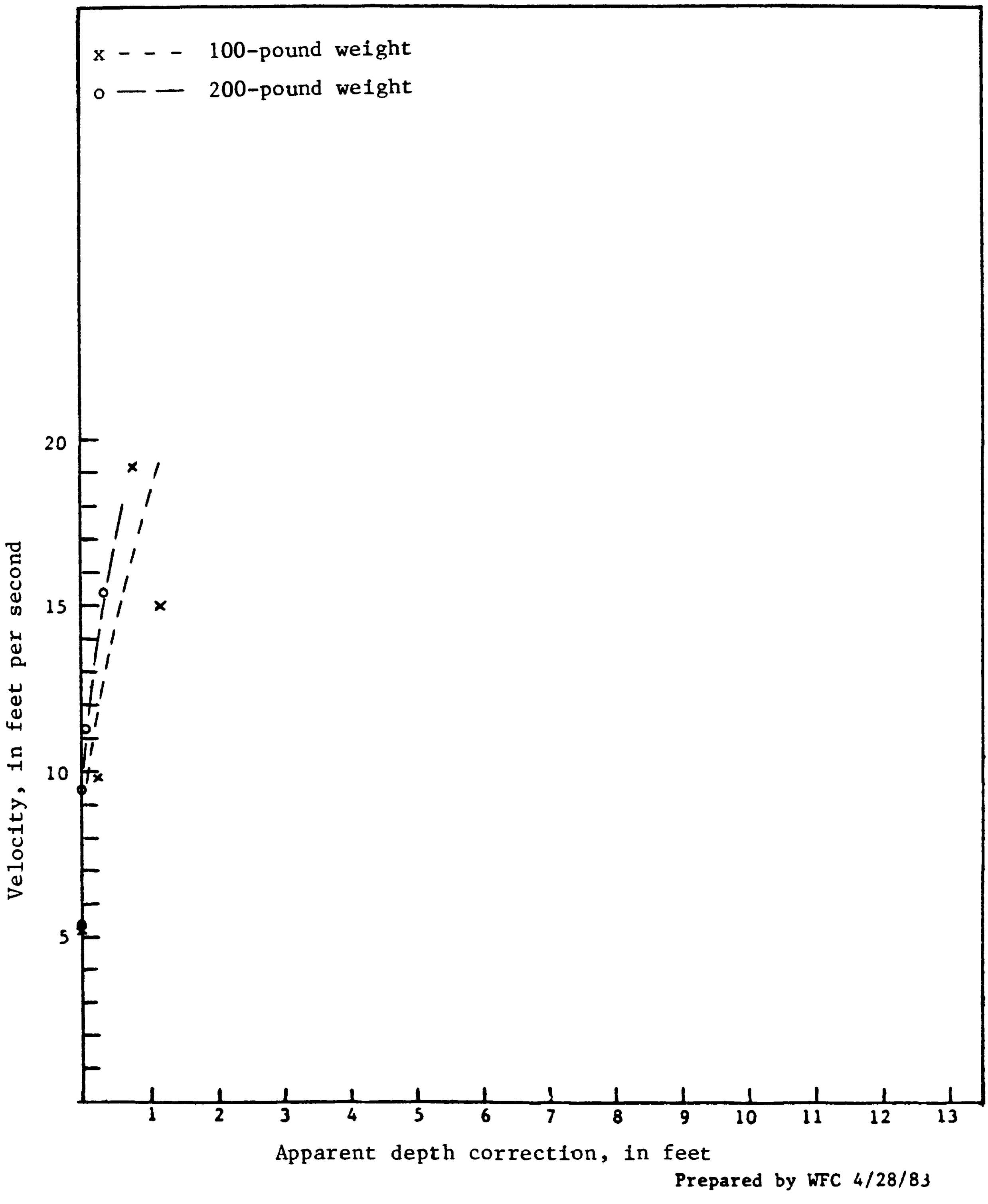
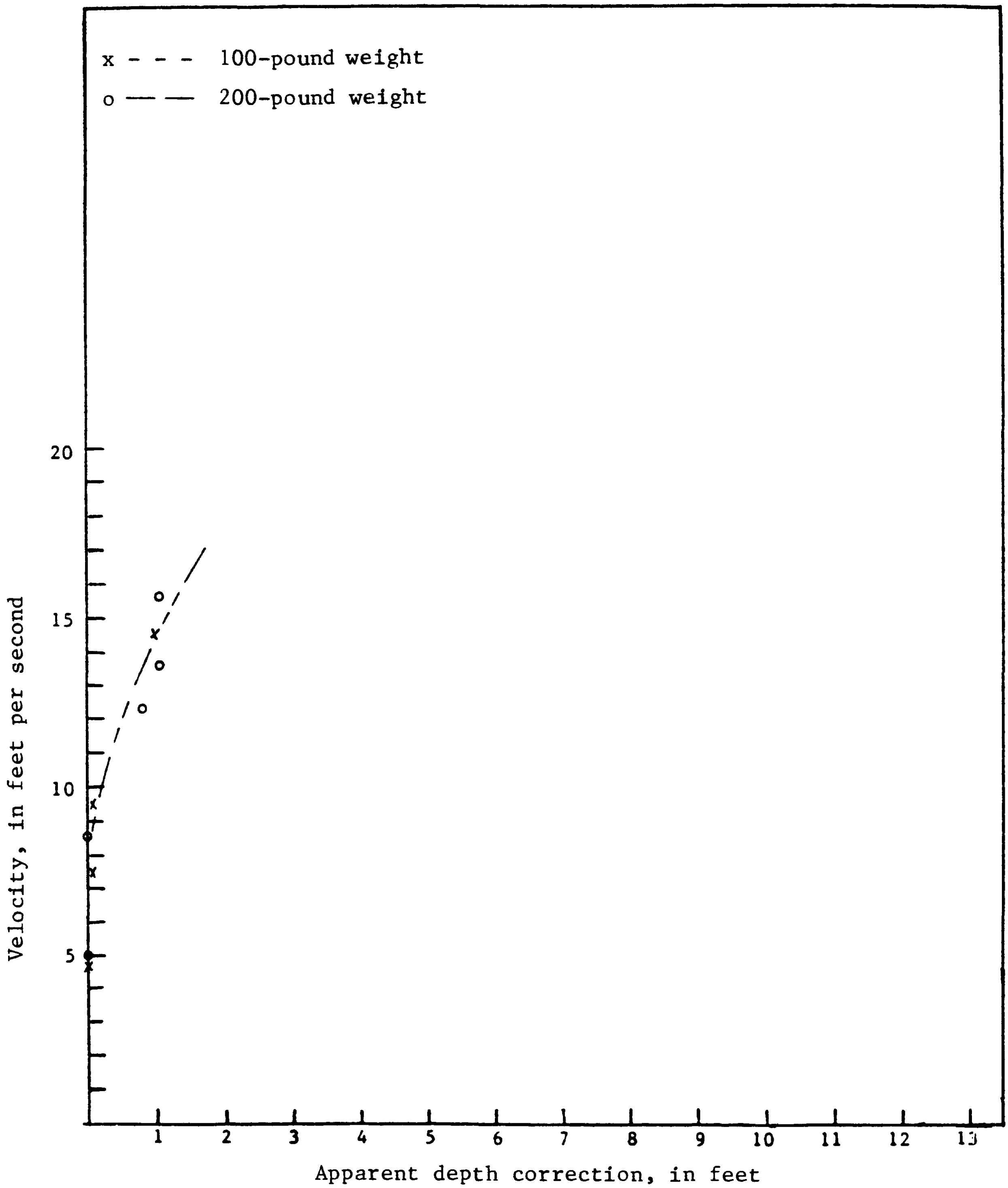


Figure 10.--Depth-correction comparison--apparent depth 5 feet.



Prepared by WFC 4/28/83

Figure 11.--Depth-correction comparison--apparent depth 10 feet.

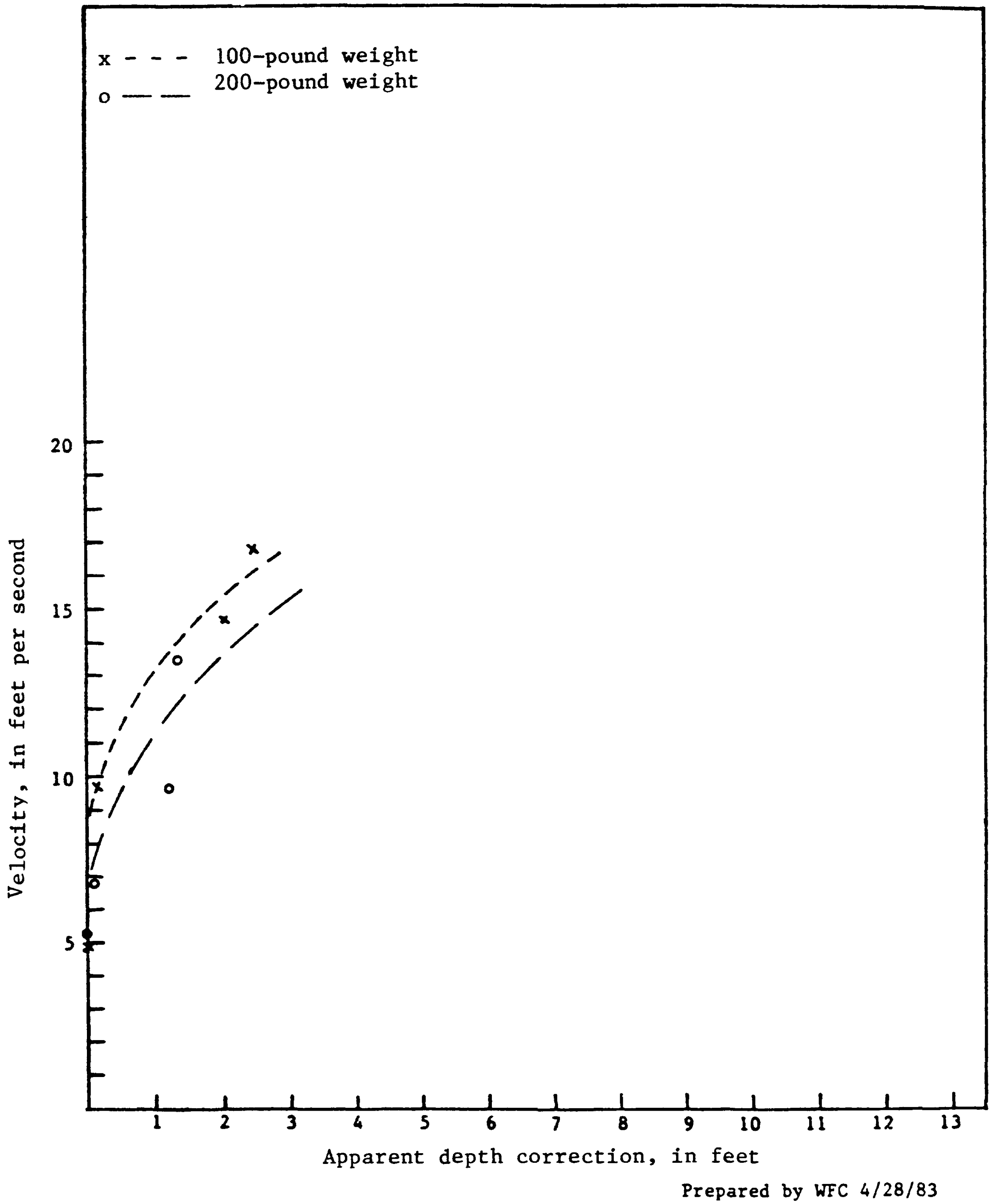


Figure 12.--Depth-correction comparison--apparent depth 20 feet.

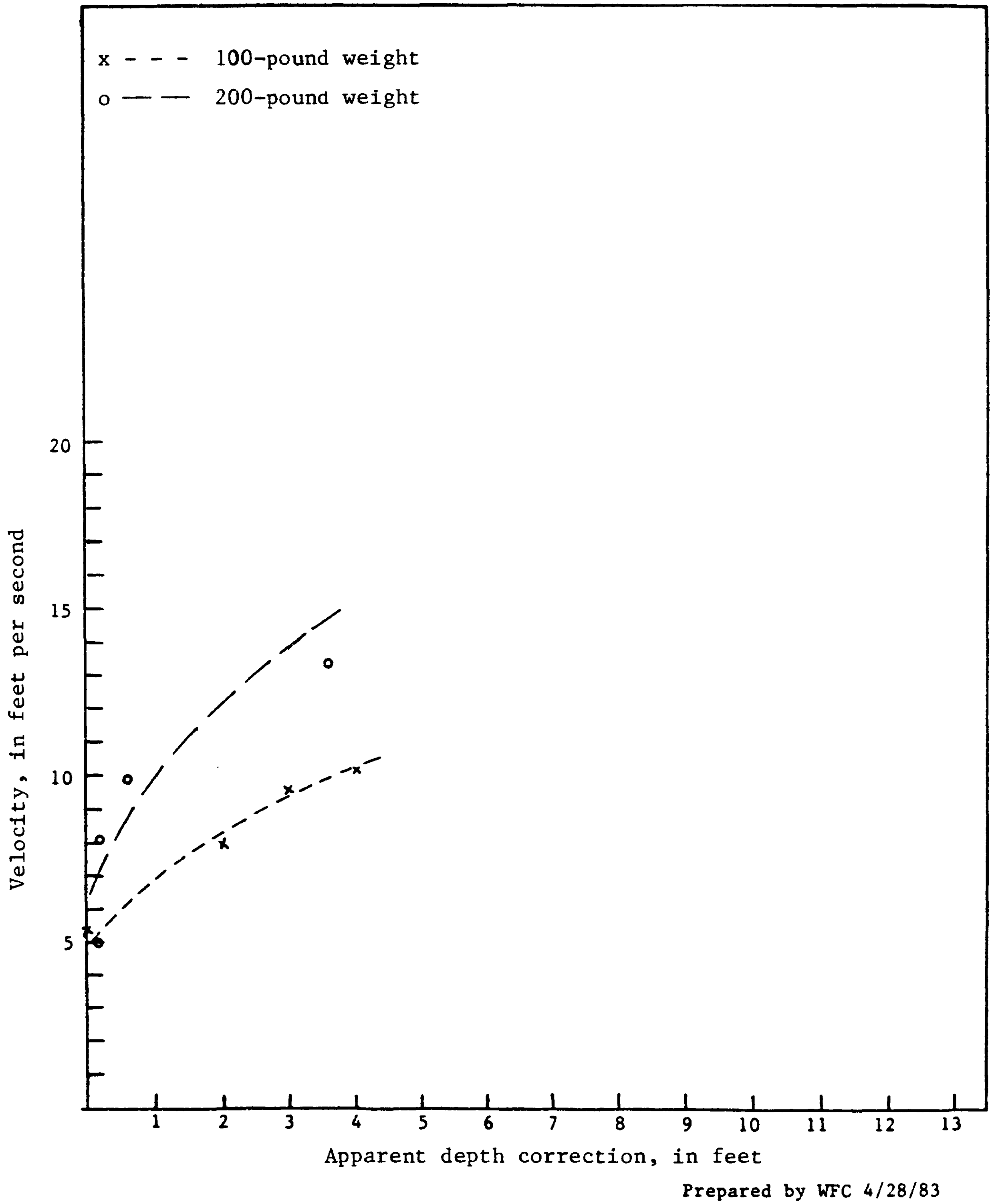


Figure 13.--Depth-correction comparison--apparent depth 40 feet.

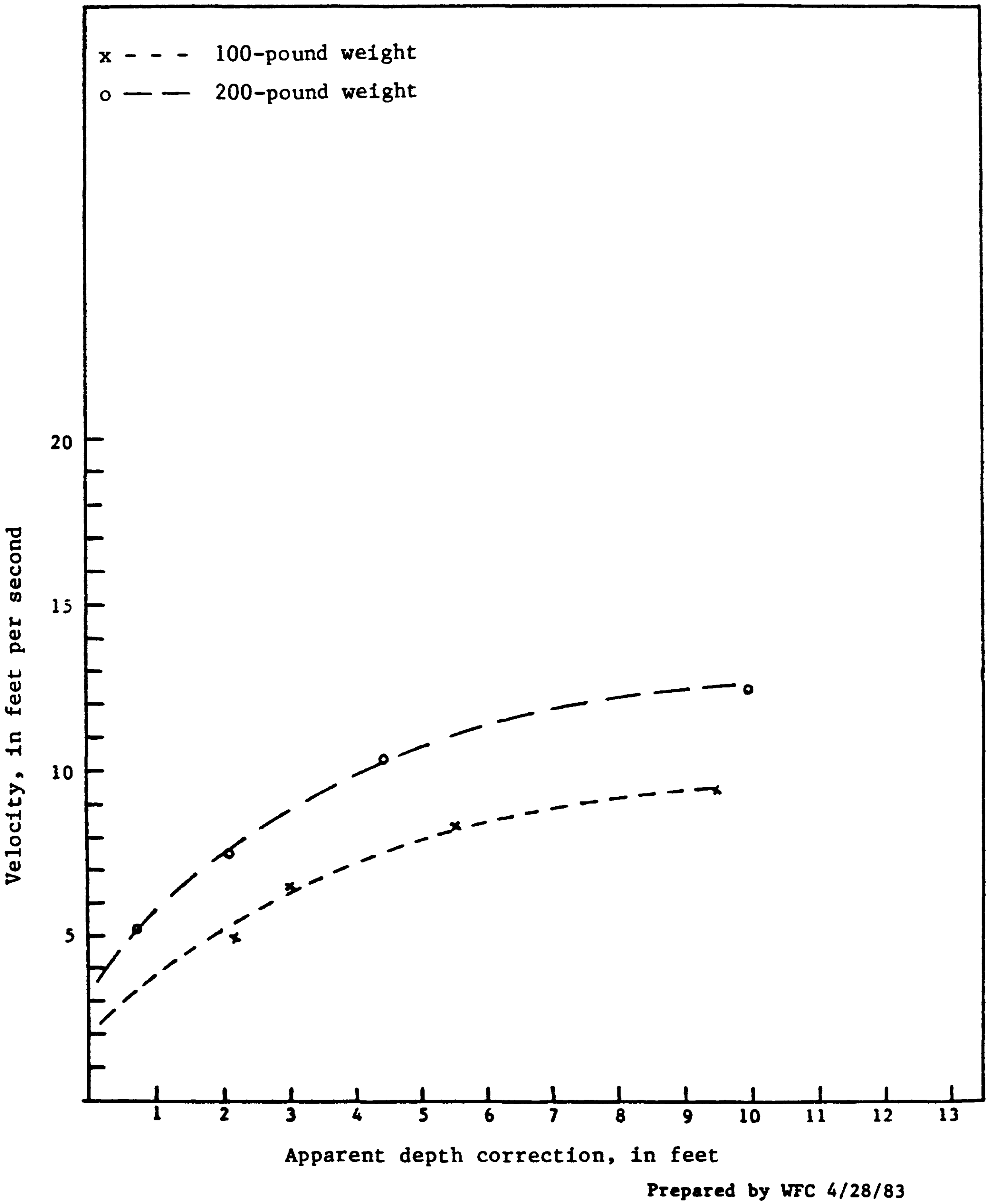


Figure 14.--Depth-correction comparison--apparent depth 70 feet.

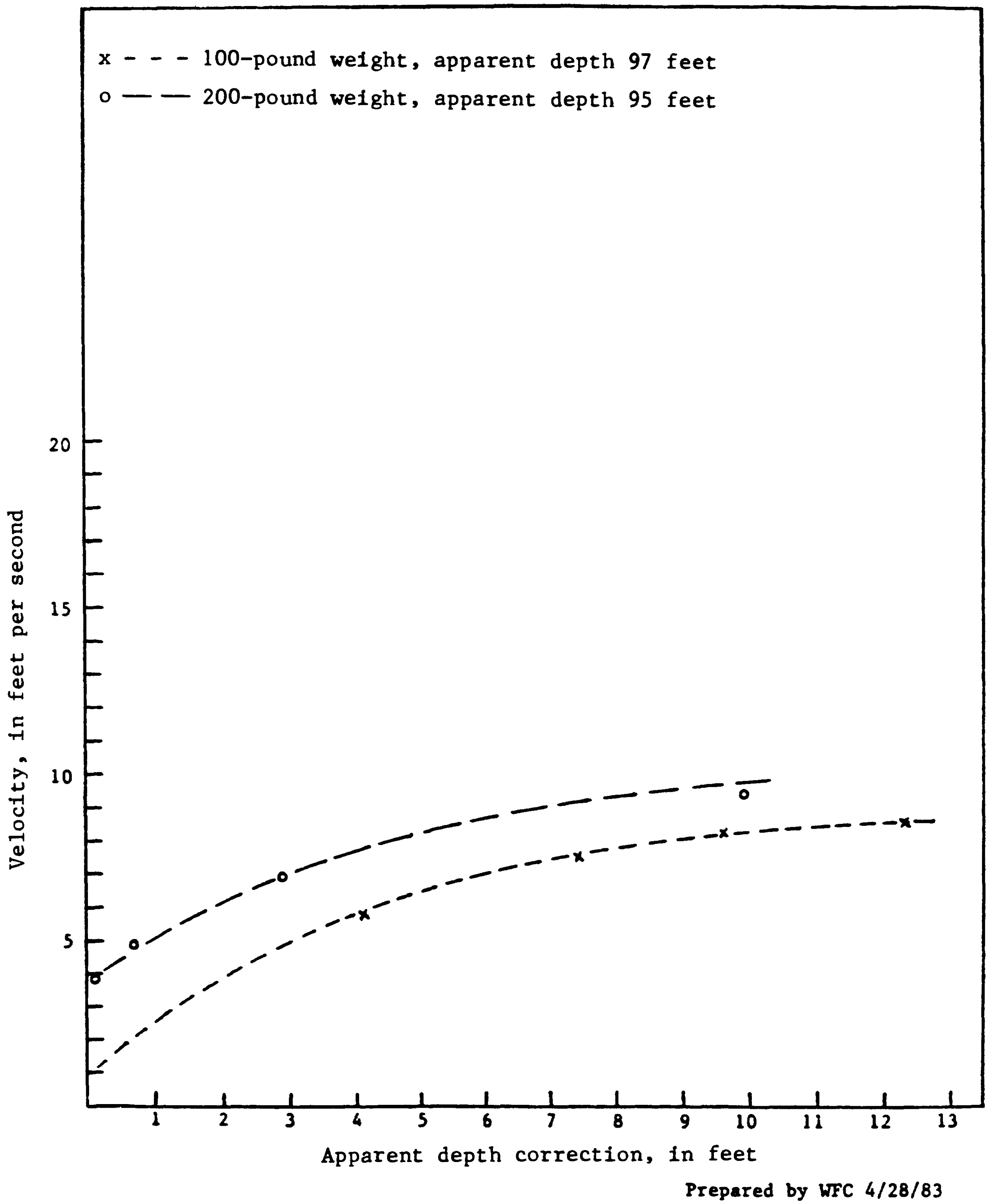


Figure 15.--Depth-correction comparison--apparent depth 96 feet.

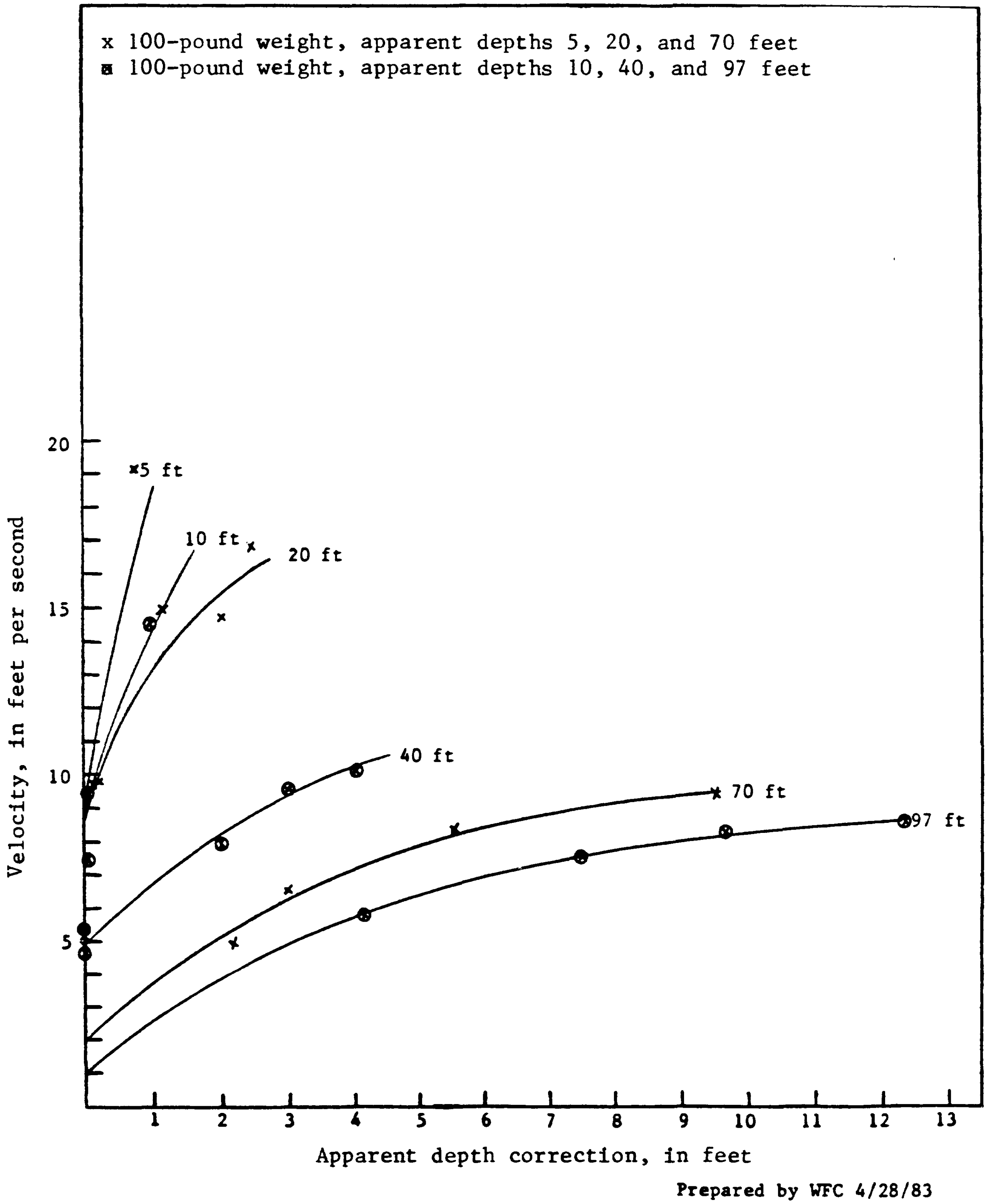


Figure 16.--Depth-correction comparison (100-pound Columbus weight used).

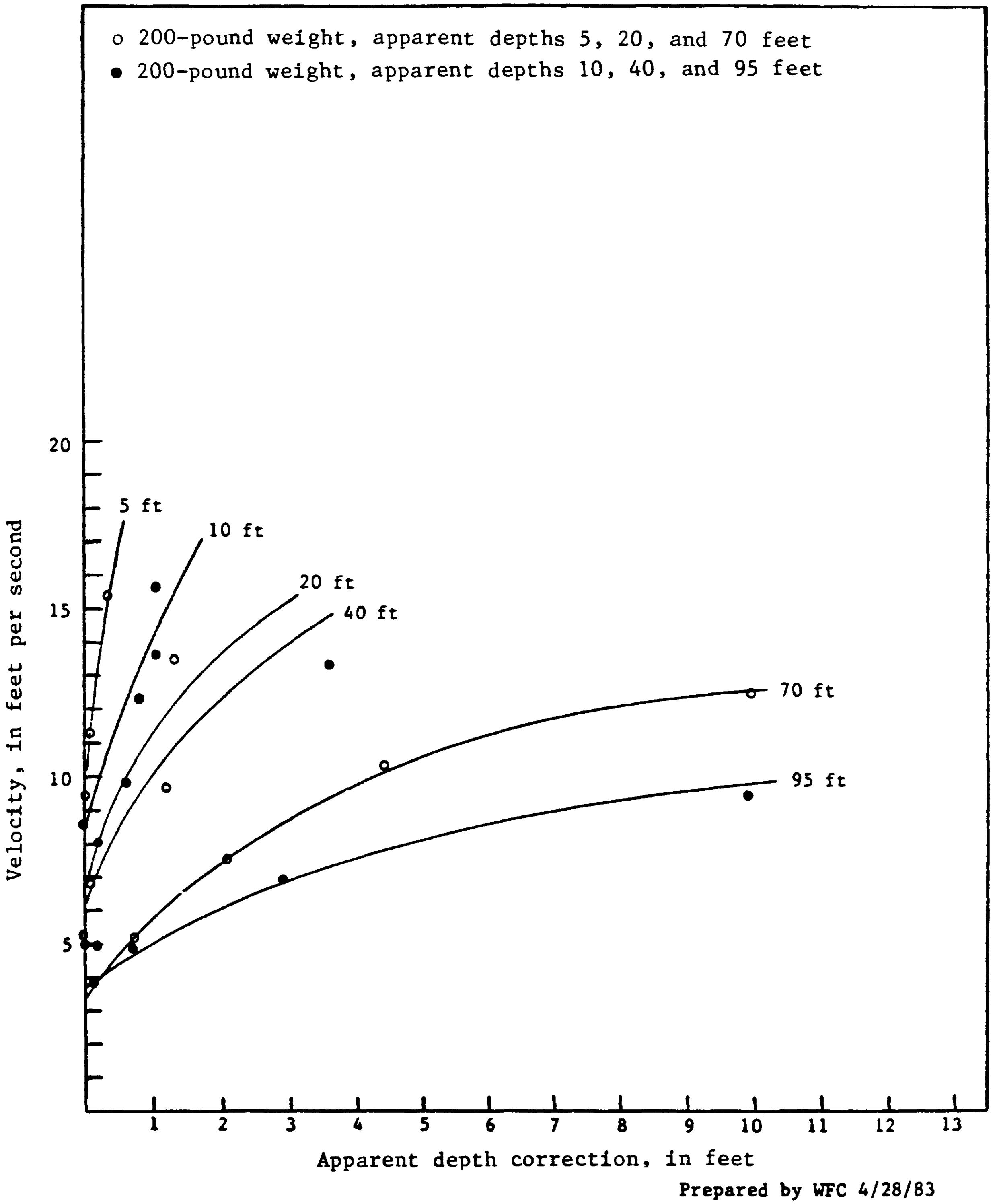


Figure 17.--Depth-correction comparison (200-pound Columbus weight used).

CONCLUSIONS

Results of this study suggest possible differences between observed depth corrections and corrections obtained from the wet-line correction table currently in use. These differences may have resulted from test conditions which deviated from the inherent assumptions of the wet-line table, as listed below.

1. Drag on the weight in the sounding position at the bottom of a stream can be neglected.

2. The distribution of horizontal drag on the sounding line is in accordance with the variation of velocity with depth.

These assumptions are inapplicable for this study since the sounding weight, as well as the entire wet-length of the sounding line, is subjected to the maximum horizontal force. However, there is significant enough variation between the test results and the wet-line correction table to suggest that the correction procedure currently used for determining the 0.8-depth setting may be in error. The results also suggest that depth corrections are dependent on the size of the sounding weight used. This is contrary to the wet-line table assumption that the table's corrections are applicable for any size sounding weight.

A more precise study would be required to resolve these differences and would necessitate developing a more accurate method of determining true depth. Such a study should be designed to use regulated rivers with normal vertical velocity distributions, or at least to minimize variation in boat speed and angle. It would also be desirable to simulate actual measuring conditions more closely by

1. attaching a current meter to the test assemblies,

2. including the most commonly used weight sizes (50, 100, 150, and 200 pounds), and

3. increasing the number of observations made at slower speeds and shallower depths (5 to 50 feet).

REFERENCES

Buchanan, T. J., and Somers, W. P., 1969, Discharge measurements at gaging stations: U.S. Geological Survey Techniques Water-Resources Investigations, book 3, chapter A8, p. 47-50.

Corbett, Don M., 1962, Stream-gaging procedure: U.S. Geological Survey Water-Supply Paper 888, 48 p.