Toyota Technical Center, U.S.A., Inc.
Arizona Proving Grounds

Drainage Calculations
Volume 2

September 1991

Prepared for:

Taisei-Bechtel Joint Venture

Prepared by:

Sverdrup Corporation
432 North 44th Street
Suite 250
Phoenix, Arizona 85008

Bradford D. Olbert

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Bradford D. Olbert

Toyota Arizona Proving Grounds
Drainage Calculations

Culvert Number / Concentration Point Listing

Listed by Culvert Number

Culvert Number	Roadway	Concentration Point	Culvert Size
1	Oval Track	70 E	(5) 10' x 5'
2	Oval Track	70 C	(1) 24" RCP
3	Oval Track	69	(3) 10' x 4'
4	Oval Track	67 E	(1) 10' x 4'
5	Oval Track	67 F	(1) 36" RCP
6	Oval Track	67 A	(5) 10' x 4'
7	Oval Track	67 B	(1) 10' x 4'
8	Oval Track	67 C	(2) 10' x 5'
9	Oval Track	67 D	(2) 10' x 4'
10	Oval Track	60 C	(1) 24" RCP
11	Oval Track	60 B	(1) 24" RCP
12	Oval Track	60 A	(5) 10' x 4'
13	Oval Track	60 F	(1) 10' x 4'
14	Oval Track	60 G	(1) 10' x 4'
15	Oval Track	60 E	(1) 24" RCP
16A	Oval Track	60 D-6	(1) 10' x 4'
16B	Oval Track	60 D-5	(1) 10' x 4'
16C	Oval Track	60 D-4	(1) 10' x 4'
16D	Oval Track	60 D-3	(1) 10' x 4'
16E	Oval Track	60 D-2	(1) 10' x 4'
16F	Oval Track	60 D-1	(1) 10' x 4'
17	Loop Road A	60 J-1	(1) 6' x 4'
18	Oval Track	60 J-2	(1) 10' x 4'
19	Loop Road A	67 H-1	(7)10' x 4'
20	Oval Track	67 H-2	(8) 10' x 4'
21	Loop Road A	67 I-1	(1) 10' x 4'

Culvert Number	Roadway	Concentration Point	Culvert Size
22	Oval Track	67 I-2	(1) 10' x 4'
23	Loop Road A	67 J-1	(1) 10' x 4'
24	Oval Track	67 J-2	(1) 10' x 4'
25	Loop Road A	67 L-1	(1) 24" RCP
26	Oval Track	67 L-2	(1) 24" RCP
27	Loop Road A	70 Q-1	(2) 10' x 5'
28	Oval Track	70 Q-2	(2) 10' x 6'
29	Loop Road A	70 P-1	(5) 10' x 6'
30	Oval Track	70 P-2	(4) 10'x 6'
31	Oval Track	70 O	(2) 10' x 4'
32	Rampway A	70 M-1	(1) 24" RCP
33	Rampway B	70 M-2	(1) 6' x 4'
34	Oval Track	76 J	(1) 10' x 4'
35	Cornering Course	70 A	(3) 10' x 5'
36	Cornering Course	70 F	(5) 10 'x 6'
37	Cornering Course	70 B	(3) 10' x 5'
38	Cornering Course	70 G	(4) 10' x 5'
39	Access Rd A-1	76 E	(2) 10' x 5'
40	Access Rd A-1	76 F	(1) 10' x 4'
41	Access Rd G-1	N/A	(1) 49" x 33" CMP Arch
42	Access Rd G-1	N/A	(2) 49" x 33" CMP Arch
43	Access Rd E-1	N/A	(2) 49" x 33" CMP Arch
44	Access Rd E-1	N/A	(2) 49" x 33" CMP Arch
45	Access Rd A-2	N/A	(1) 49" x 33" CMP Arch
46	Access Rd A-2	N/A	(2) 49" x 33" CMP Arch
47	Access Rd A-2	N/A	(2) 49" x 33" CMP Arch

Listed by Concentration Point

Concentration Point	Roadway	Culvert Number	Culvert Size
60 A	Oval Track	12	(5) 10' x 4'
60 B	Oval Track	11	(1) 24" RCP
60 C	Oval Track	10	(1) 24" RCP
60 D-1	Oval Track	16F	(1) 10' x 4'
60 D-2	Oval Track	16E	(1) 10' x 4'
60 D-3	Oval Track	16D	(1) 10' x 4'
60 D-4	Oval Track	16C	(1) 10' x 4'
60 D-5	Oval Track	16B	(1) 10' x 4'
60 D-6	Oval Track	16A	(1) 10' x 4'
60 E	Oval Track	15	(1) 24" RCP
60 F	Oval Track	13	(1) 10' x 4'
60 G	Oval Track	14	(1) 10' x 4'
60 J-1	Loop Road A	17	(1) 6' x 4'
60 J-2	Oval Track	18	(1) 10' x 4'
67 A	Oval Track	6	(5) 10 'x 4'
67 B	Oval Track	7	(1) 10' x 4'
67 C	Oval Track	8	(2) 10' x 5'
67 D	Oval Track	9	(2) 10' x 4'
67 E	Oval Track	4	(1) 10' x 4'
67 F	Oval Track	5	(1) 36" RCP
67 H-1	Loop Road A	19	(7)10' x 4'
67 H-2	Oval Track	20	(8) 10' x 4'
67 I-1	Loop Road A	21	(1) 10' x 4'
67 I-2	Oval Track	22	(1) 10' x 4'
67 J-1	Loop Road A	23	(1) 10' x 4'
67 J-2	Oval Track	24	(1) 10' x 4'

Concentration Point	Roadway	Culvert Number	Culvert Size
67 L-1	Loop Road A	25	(1) 24" RCP
67 L-2	Oval Track	26	(1) 24" RCP
69	Oval Track	3	(3) 10' x 4'
70 A	Cornering Course	35	(3) 10' x 5'
70 B	Cornering Course	37	(3) 10' x 5'
70 C	Oval Track	2	(1) 24" RCP
70 E	Oval Track	1	(5) 10' x 5'
70 M-1	Rampway A	32	(1) 24" RCP
70 M-2	Rampway B	33	(1) 6' x 4'
70 O	Oval Track	31	(2) 10' x 4'
70 P-1	Loop Road A	29	(5) 10' x 6'
70 P-2	Oval Track	30	(4) 10 'x 6'
70 Q-1	Loop Road A	27	(2) 10 'x 5'
70 Q-2	Oval Track	28	(2) 10 'x 6'
76 E	Access Rd A-1	39	(2) 10 'x 5'
70 F	Cornering Course	36	(5) 10 'x 6'
76 F	Access Rd A-1	40	(1) 10' x 4'
70 G	Cornering Course	38	(4) 10 'x 5'
76 J	Oval Track	34	(1) 10' x 4'
N/A	Access Rd G-1	41	(1) 49" x 33" CMP Arch
N/A	Access Rd G-1	42	(2) 49" x 33" CMP Arch
N/A	Access Rd E-1	43	(2) 49" x 33" CMP Arch
N/A	Access Rd E-1	44	(2) 49" x 33" CMP Arch
N/A	Access Rd A-2	45	(1) 49" x 33" CMP Arch
N/A	Access Rd A-2	46	(2) 49" x 33" CMP Arch
N/A	Access Rd A-2	47	(2) 49" x 33" CMP Arch

SVERDRUP

JOB 4077 Toyota

COMPUTATIONS FOR Culvert 67 L-1 [25]

SHEET NO ____ OF ____

DATE 7-12-91

BY DFP CHKD RJT

CULVERT COMPUTATION SHEET

PROJECT: ____

STATION: 35+25 Loop Road 1

DESIGNER: ____

DATE: 8-19-91

HYDROLOGIC AND CHANNEL INFORMATION

DRAINAGE AREA ____

Q_1 = 31 cfs

Q_2 = ____

TW_1 = 2.25 (1)

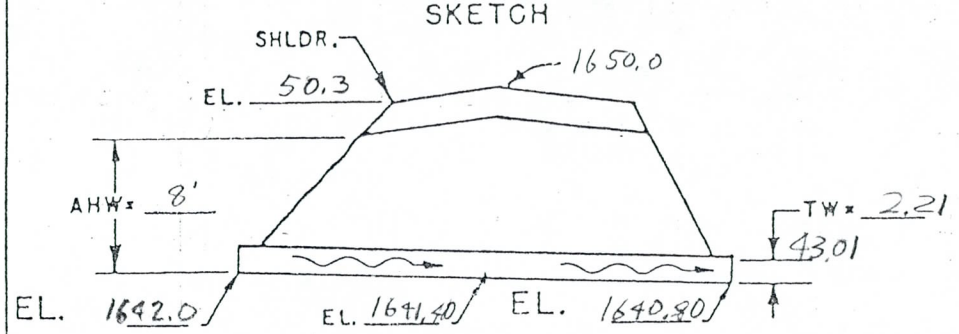
TW_2 = 2.21 (2)

Peak Discharge Q_{100}

(Q_1 = DESIGN DISCHARGE, SAY ~~Q_{25}~~)

(Q_2 = CHECK DISCHARGE, SAY Q_{50})

SKETCH



S_0 = .01 L = 120' L/100 S_0 = ____

MEAN STREAM VELOCITY = 1.0 ft/s

CULVERT DESCRIPTION SIZE	CULVERT DESCRIPTION ENTR. TYPE	Q	CAP. CHART HW	HEADWATER COMPUTATION: INLET CONT. HW/D	INLET CONT. HW	OUTLET CONTROL HW = H + h_o − LS_o: K_e	H	d_c	$\frac{d_c + D}{2}$	TW	h_o	LS_o	HW	CONTROL HW	OUTLET VELOCITY	COST	DHW ELEV.	COMMENTS
24"RCP	Headwall	31 cfs		2.15	4.30	.2	3.70	1.9	1.95	2.25	2.25	.60	5.35	5.35	7.87		1647.35	Outlet Control (1)
"	"	"		2.15	4.30	.2	3.70	1.9	1.95	2.21	2.21	1.20	4.73	4.71	9.87		1646.71	Outlet Control (2)

SUMMARY & RECOMMENDATIONS (1) S=.015 Based on DHWE 1643.65 from culvert 67 L-2 and Culvert 67 L-1 outlet Invert 1641.40

(2) S=0.01 Based on DHWE 1643.01 from Culvert 67 L-2 and Culvert 67 L-1 outlet Invert 1640.80

SVERDRUP

JOB 40[illegible]77 Toyota

COMPUTATIONS FOR Culvert 67 L-2 [26]

SHEET NO. _____ OF _____

DATE 7-12-91

BY DFP CHKD RJT

CULVERT COMPUTATION SHEET

PROJECT: High Speed Track

STATION: 36+25 HDP

DESIGNER: _____

DATE: 8-19-91

HYDROLOGIC AND CHANNEL INFORMATION

DRAINAGE AREA _____

Q_1 = 31 cfs

Q_2 = _____

TW_1 = 1.10'*

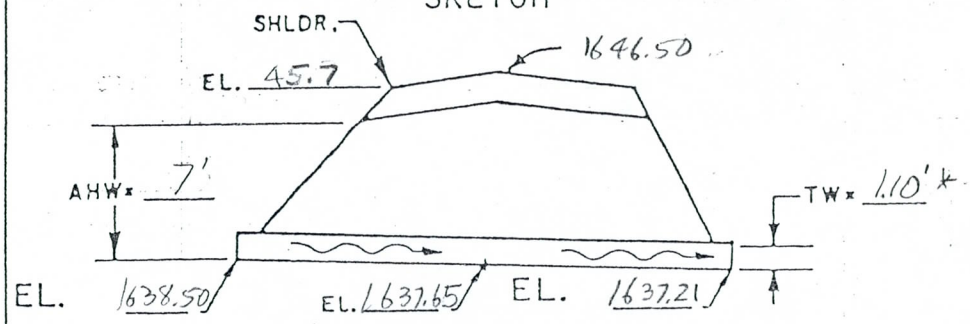
TW_2 = _____

Peak Discharge Q_{100}

(Q_1 = DESIGN DISCHARGE, SAY ~~Q_{25}~~)

(Q_2 = CHECK DISCHARGE, SAY Q_{50})

SKETCH



S_0 = .01 L = 129' L/100 S_0 = _____

MEAN STREAM VELOCITY = 1.63 ft/s

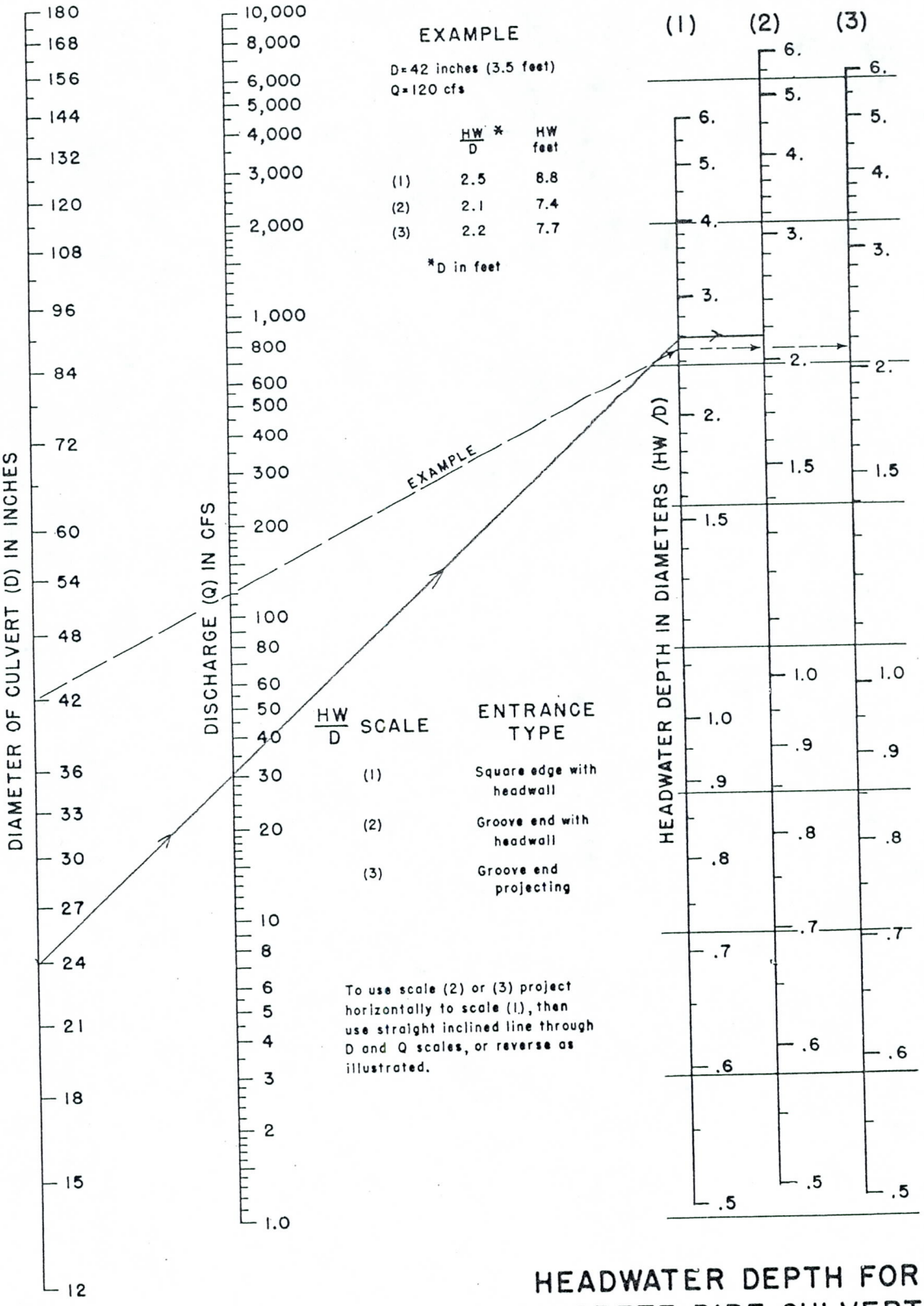
CULVERT DESCRIPTION		Q	CAP. CHART HW	HEADWATER COMPUTATION											CONTROL HW	OUTLET VELOCITY	COST	DHW ELEV.	COMMENTS
				INLET CONT.		OUTLET CONTROL HW = H + h_o − LS_o													
SIZE	ENTR. TYPE			HW/D	HW	K_e	H	d_c	$\frac{d_c + D}{2}$	TW	h_o	LS_o	HW						
24" RCP	Headwall	31 cfs		2.15	4.30	.2	3.85	1.9	1.95	1.10	1.95	.65	5.15		5.15	10.06		1643.65	Outlet Control (1)
				2.15	4.30	.2	3.85	1.9	1.95	1.10	1.95	1.29	4.51		4.51	10.06		1643.01	Outlet Control (2)

SUMMARY & RECOMMENDATIONS * Derived from existing downstream channel cross section. (1) S = .005 (2) S = .01

Use Selection # 2

Culverts 67 L-1
67 L-2

CHART 1



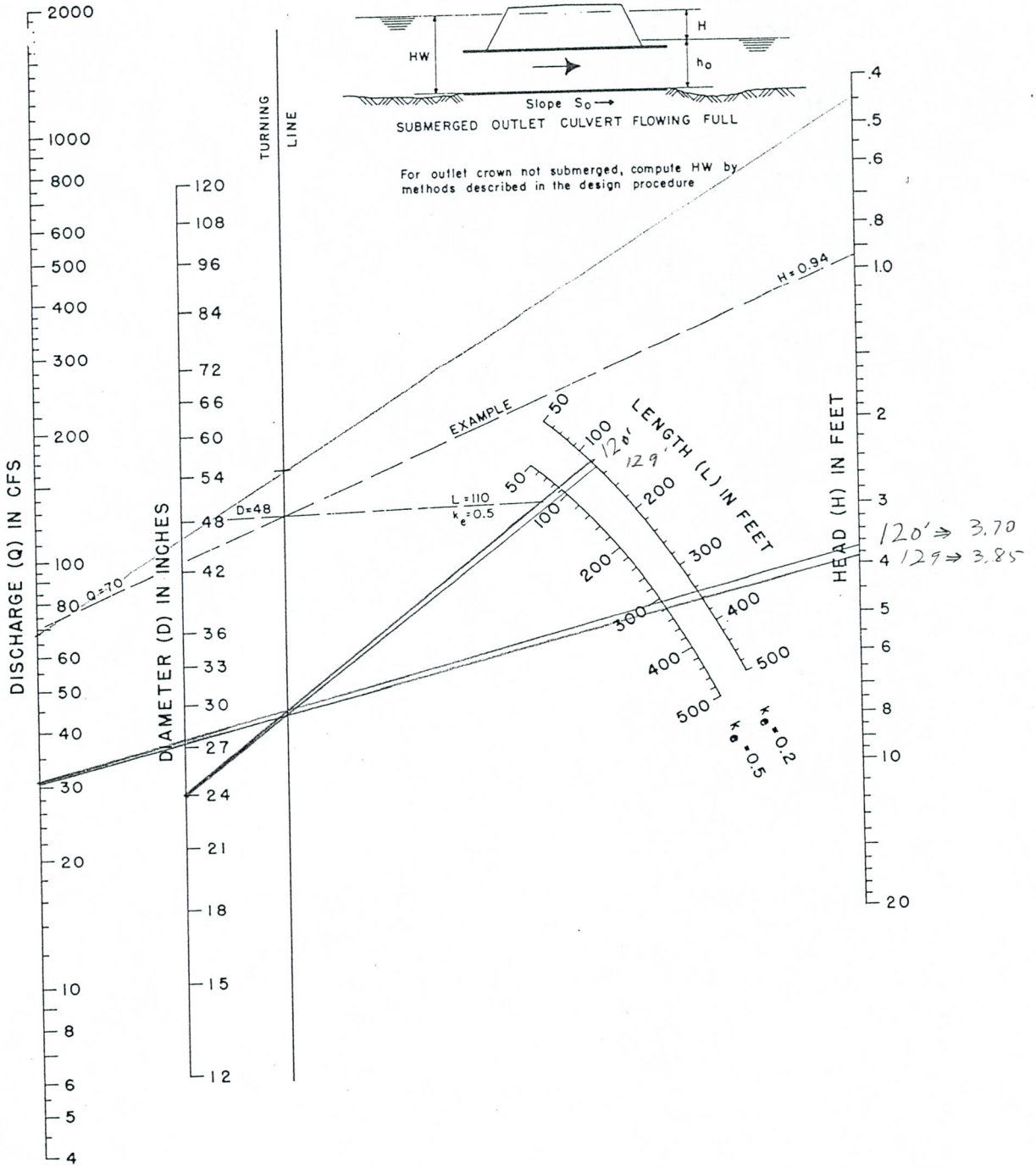
HEADWATER DEPTH FOR CONCRETE PIPE CULVERTS WITH INLET CONTROL

HEADWATER SCALES 2&3
REVISED MAY 1964

BUREAU OF PUBLIC ROADS JAN. 1963

67L-1 & 67L-2 4/18

CHART 5

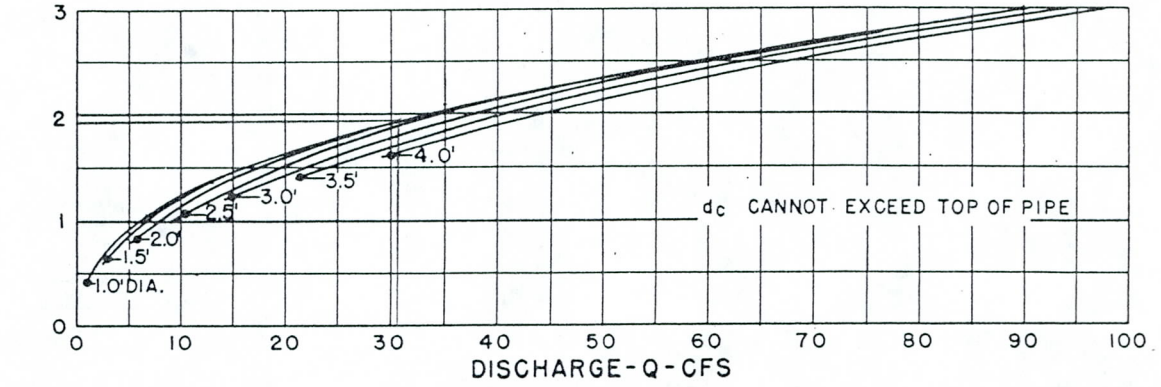


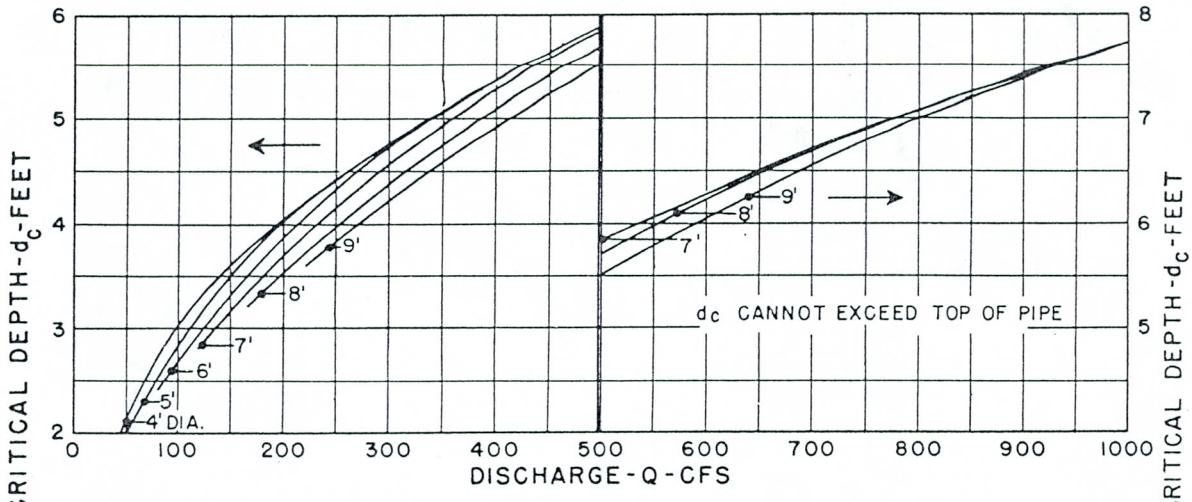
HEAD FOR CONCRETE PIPE CULVERTS FLOWING FULL n = 0.012

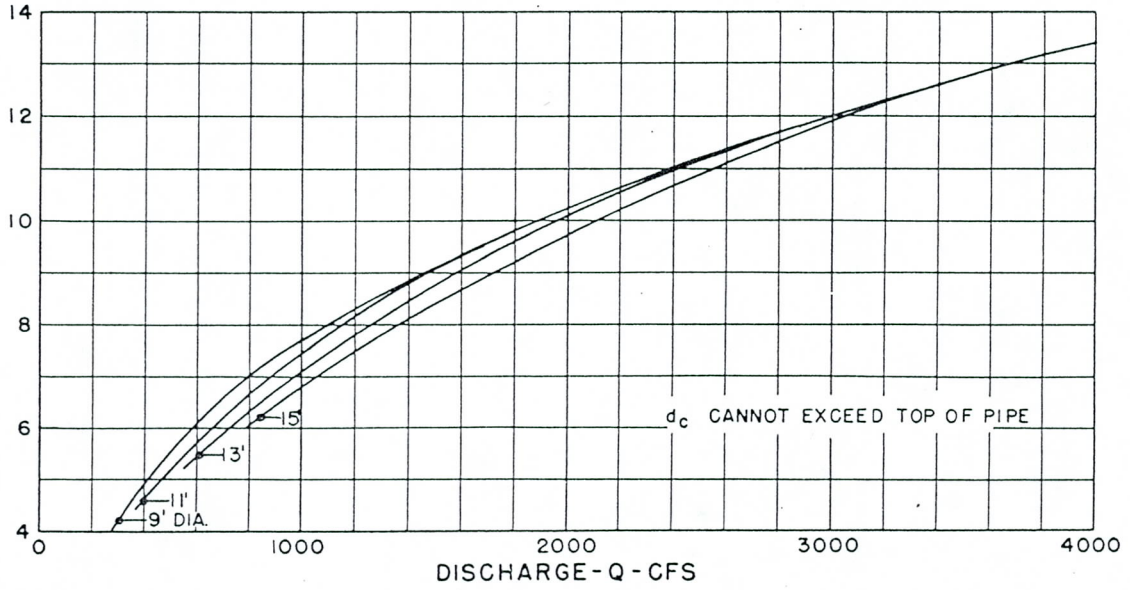
BUREAU OF PUBLIC ROADS JAN. 1963

Culverts 67L-1
67L-2

CHART 4







BUREAU OF PUBLIC ROADS

JAN. 1964

CRITICAL DEPTH
CIRCULAR PIPE

Determine Flow Characteristics in Pipes:

For both culverts, $n = .012$, $S = .01$, $D = 2'$, $Q = 31$ cfs

d = depth of flow in pipe

For 67L-1:

$TW/D = \frac{2.21'}{2'} = 1.11 > 1.00 \therefore y_o = D = 2'$

$V = Q/A = \frac{31}{\frac{\pi 2^2}{4}} = 9.87$ ft/s

$y_e = \left(\frac{A}{2'}\right)^{1/2} = \left(\frac{\pi 2^2}{4(2)}\right)^{1/2} = 1.25'$

$N_F = \frac{V}{\sqrt{32.2\, y_e}} = \frac{9.87}{\sqrt{32.2(1.25)}} = 1.56$

For 67L-2:

From HEC 14, Fig III-10 with

$TW/D = \frac{11}{2} = 0.55 \quad \frac{Q}{D^{2.5}} = \frac{31}{2^{2.5}} = 5.48$

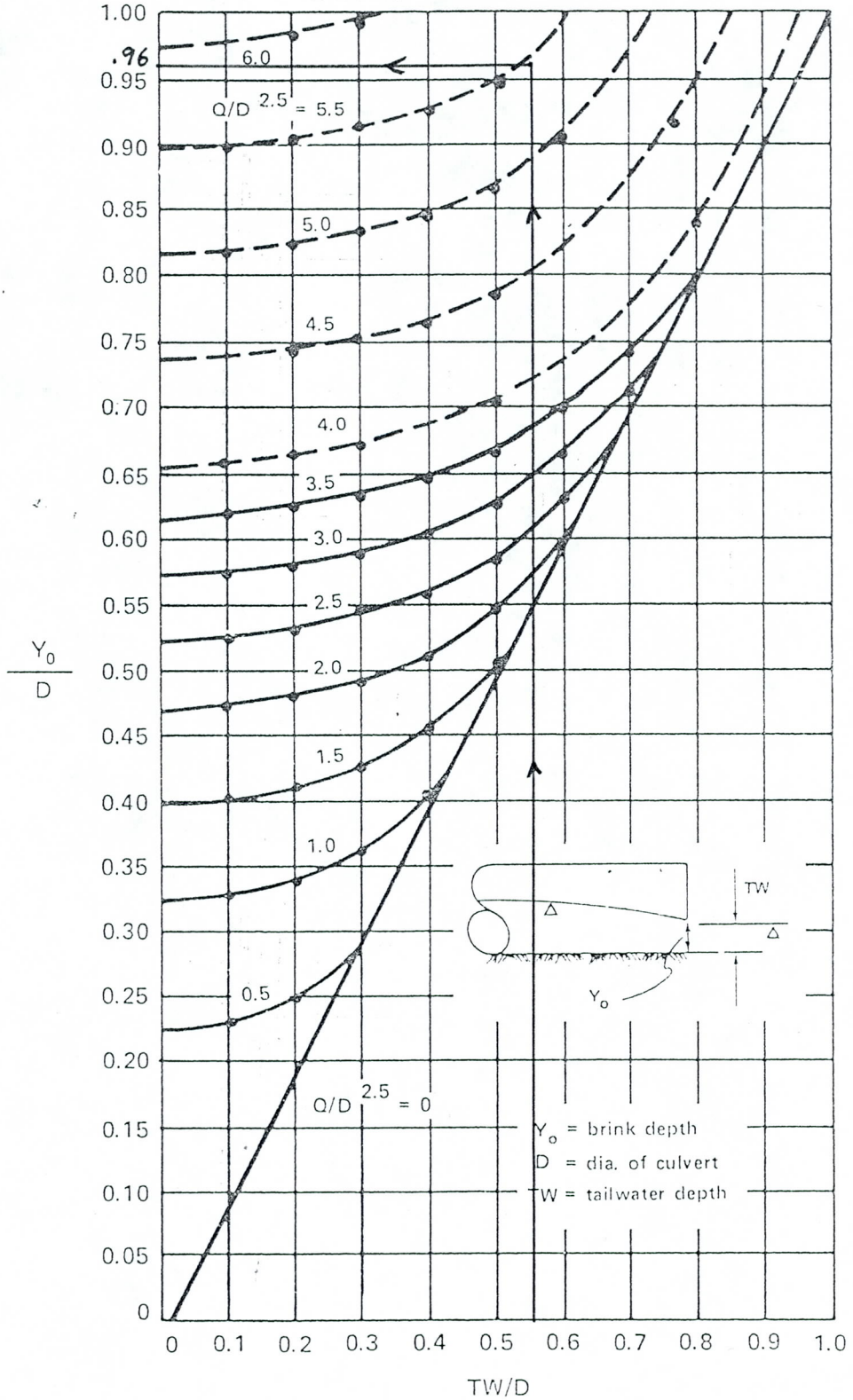
$y_o = 0.96(2) = 1.92$. Critical depth ($y_c = 1.9'$) should have been larger than brink depth, so use $y_o = 1.9'$

From HEC 14, Table III-2 with $\frac{d}{D} = \frac{y_o}{D} = \frac{1.9}{2} = .95$

$\Rightarrow \frac{A}{D^2} = 0.7707 \quad A = 0.7707(2)^2 = 3.08$ ft^2

$V_o = \frac{Q}{A} = \frac{31}{3.08} = 10.06$ ft/s. $y_e = \left(\frac{A}{2}\right)^{1/2} = \left(\frac{3.08}{2}\right)^{1/2} = 1.24'$

$N_F = \frac{V_o}{\sqrt{g\, y_e}} = \frac{10.06}{\sqrt{32.2(1.24)}} = 1.59$



HEC 14,

Figure III-10 Dimensionless Rating Curve for the Outlets of Circular Culverts on Horizontal and Mild Slopes from Reference III-2

Design Channel Between Culverts:

Determine Channel Slope:

$$S = \frac{1640.80 - 1638.50}{(402.5 \div \cos 14°) - 60 - 85} = \frac{2.30}{269.82} = 0.008524$$

$$= 0.8524\%$$

From Mannings Formula, where $S = .008524\%$, $w = 6'$, 4:1 side slopes, $n = .02$, $\Rightarrow$ $y_n = 0.75'$ $V = 4.62\ ft/s$ (for Soil Cement Channel) $A = 6.71\ ft^2$ $T = 11.98'$ $N_F = \frac{V}{\sqrt{g\,A/T}} = 1.09$

Determine Height of Channel Walls:

Min freeboard = 1' or $\frac{1}{6}\left(y_n + \frac{V^2}{2g}\right) = .18$ use 1'

Channel Height = .75 + 1' = 1.75' use 2'

Channel Downstream of Culvert 67L-2:

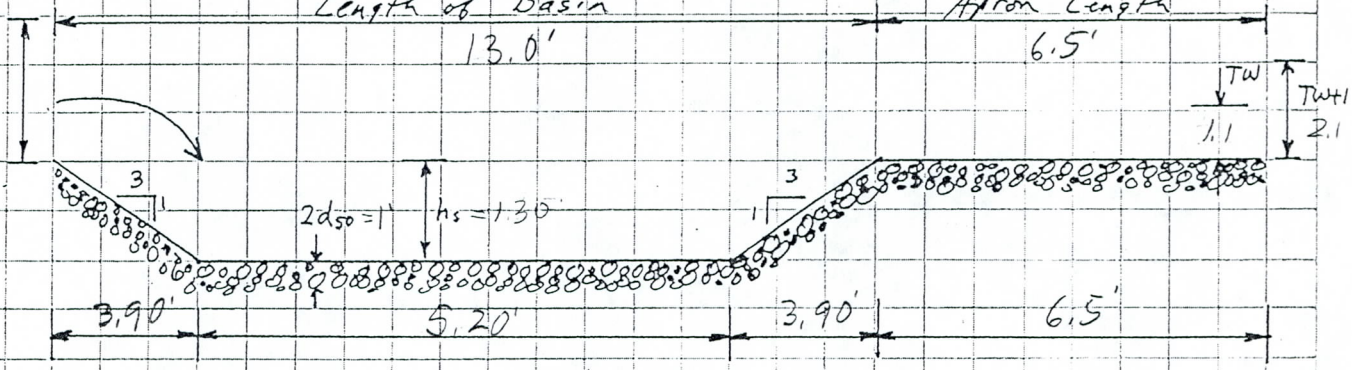
Existing Ground appears to be nearly matching the outlet of the plunge basin. We specified grading 100' downstream of the plunge basin apron to provide for a transition to existing ground.

SVERDRUP

JOB 40477 Toyota SHEET NO. 9 OF 18

COMPUTATIONS FOR Box Culvert 67L-2 DATE 8/20/91 BY DFP CHKD RJT

Riprap Plunge Basin Design (Q_{10})



Check Rock Size (From X1-2, HEC No. 14)

For $y_o = 1.9'$ $y_c = 1.24'$ $d_{50} = 6'$ or $5'$

$d_{50}/y_c = 1.5/1.24 = 0.40$ $N_F = 1.59 < 3$ Plunge Basin OK

$h_s/y_c = 1.05$ $h_s = 1.05(1.24) = 1.30$

check $\frac{h_s}{d_{50}} = \frac{1.30}{.5} = 2.60 < 4$ but > 2 OK

Length of Basin:

$10\,h_s = 10(1.30) = 13.0'$

or

$3(W_o) = 3(2) = 6'$ Use 13.0'

Apron Length:

$5h_s = 5(1.30) = 6.5'$

$W_o = 2'$ use 6.5'

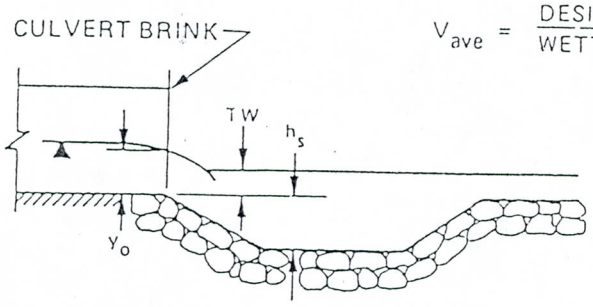
Top of Riprap:

$TW + 1 = 1.1 + 1 = 2.1'$

Use 3'

$TW/y_o = \frac{1.1}{1.9} = 0.58, < .75 \therefore$ No Add'l Downstream Riprap Req'd

10/18



$$V_{ave} = \frac{\text{DESIGN DISCHARGE} - Q}{\text{WETTED AREA AT BRINK OF CULVERT}}$$

d_{50} = THE MEDIAN SIZE OF ROCK BY WEIGHT. ROUNDED ROCK OR ANGULAR ROCK.

Y_e = EQUIVALENT BRINK DEPTH

= BRINK DEPTH FOR BOX CULVERT

$= \left(\frac{A}{2}\right)^{1/2}$ FOR NON–RECTANGULAR SECTIONS

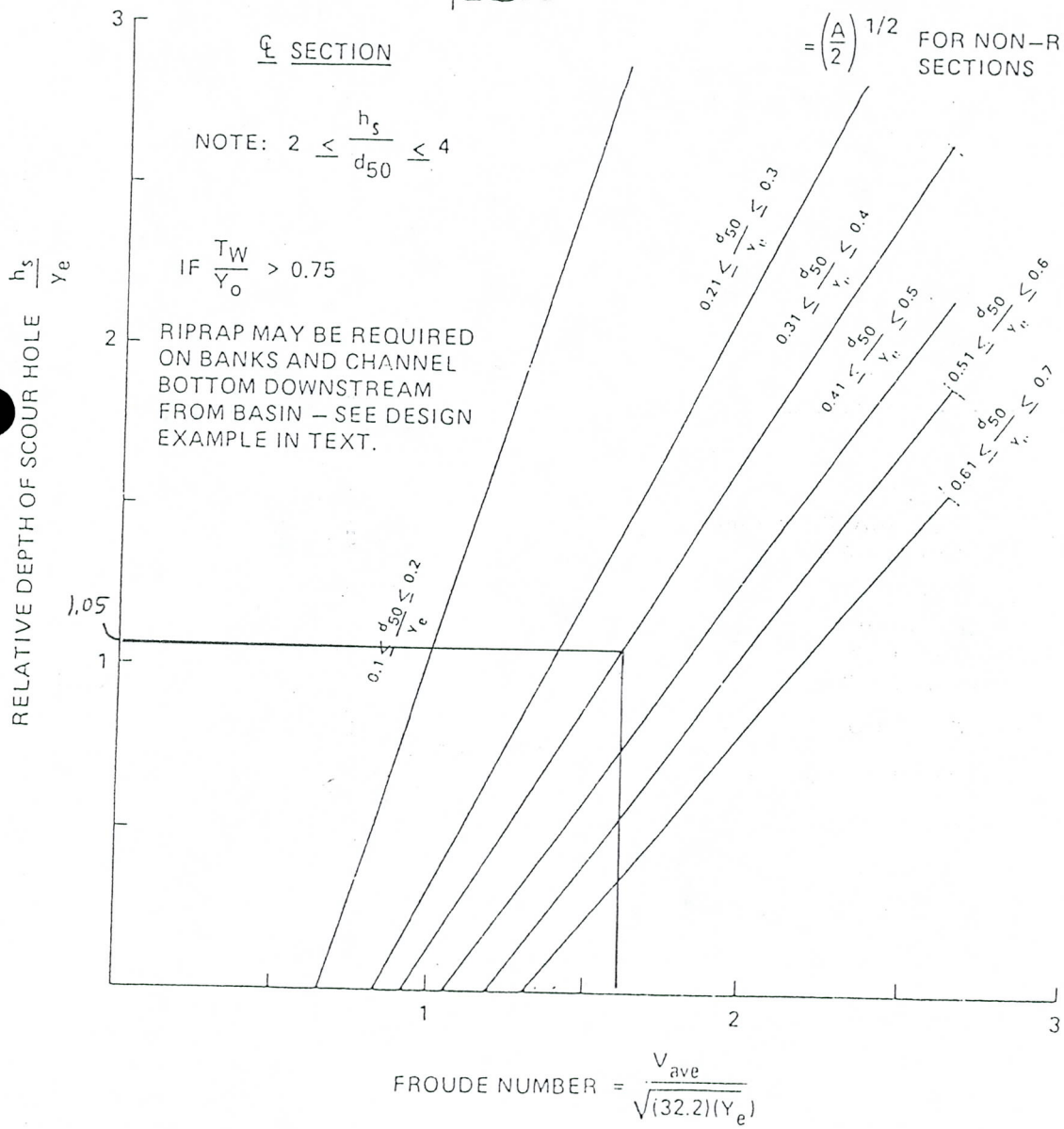


FIGURE X1–2. RELATIVE DEPTH OF SCOUR HOLE VERSUS FROUDE NUMBER AT BRINK OF CULVERT WITH RELATIVE SIZE OF RIPRAP AS A THIRD VARIABLE

SECTION NUMBER TW67L 6/10/91

Channel Slope: 0.0055 ft./ft.

CROSS SECTION DATA:

OFFSET	-650	-600	-300	-80	0	30.8	121.4	122.4	125.2	126.7	221.1	270
ELEV.	40	38	39	38	38.3	38.36	37.34	36.7	36.87	37.51	38.31	40
N	N/A	0.035	0.035	0.035	0.035	0.035	0.035	0.035	0.025	0.035	0.035	0.035

STAGE-DISCHARGE DATA:

STAGE: 36.7												
WET PER.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
AREA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYD.RAD.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Q	0	0	0	0	0	0	0	0	0	0	0	0

STAGE: 36.85												
WET PER.	0.0	0.0	0.0	0.0	0.0	0.0	0.3	2.5	0.0	0.0	0.0	0.0
AREA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0
HYD.RAD.	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.0
Q	0	0	0	0	0	0	0	0	0	0	0	0

STAGE: 37												
WET PER.	0.0	0.0	0.0	0.0	0.0	0.0	0.6	2.8	0.3	0.0	0.0	0.0
AREA	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.6	0.0	0.0	0.0	0.0
HYD.RAD.	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.1	0.0	0.0	0.0
Q	0	0	0	0	0	0	0	1	0	0	0	0

STAGE: 37.15												
WET PER.	0.0	0.0	0.0	0.0	0.0	0.0	0.8	2.8	0.7	0.0	0.0	0.0
AREA	0.0	0.0	0.0	0.0	0.0	0.0	0.2	1.0	0.1	0.0	0.0	0.0
HYD.RAD.	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.4	0.1	0.0	0.0	0.0
Q	0	0	0	0	0	0	0	2	0	0	0	0

STAGE: 37.3												
WET PER.	0.0	0.0	0.0	0.0	0.0	0.0	1.1	2.8	1.1	0.0	0.0	0.0
AREA	0.0	0.0	0.0	0.0	0.0	0.0	0.3	1.4	0.2	0.0	0.0	0.0
HYD.RAD.	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.5	0.2	0.0	0.0	0.0
Q	0	0	0	0	0	0	0	4	0	0	0	0

STAGE: 37.45												
WET PER.	0.0	0.0	0.0	0.0	0.0	9.8	11.0	2.8	1.5	0.0	0.0	0.0
AREA	0.0	0.0	0.0	0.0	0.0	0.5	1.0	1.9	0.4	0.0	0.0	0.0
HYD.RAD.	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.7	0.3	0.0	0.0	0.0
Q	0	0	0	0	0	0	1	6	1	0	0	0

11/18

SECTION NUMBER TW67L 6/10/91

STAGE:	37.6											
WET PER.		0.0	0.0	0.0	0.0	0.0	23.1	24.3	2.8	1.6	12.3	0.0	0.0
AREA		0.0	0.0	0.0	0.0	0.0	3.0	3.6	2.3	0.6	1.1	0.0	0.0
HYD.RAD.		0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.8	0.4	0.1	0.0	0.0
Q		0	0	0	0	0	0	3	9	0	1	0	0
STAGE:	37.75											
WET PER.		0.0	0.0	0.0	0.0	0.0	36.4	37.6	2.8	1.6	30.0	0.0	0.0
AREA		0.0	0.0	0.0	0.0	0.0	7.5	8.2	2.7	0.8	4.2	0.0	0.0
HYD.RAD.		0.0	0.0	0.0	0.0	0.0	0.2	0.2	1.0	0.5	0.1	0.0	0.0
Q		0	0	0	0	0	0	9	12	0	4	0	0
STAGE:	37.9											
WET PER.		0.0	0.0	0.0	0.0	0.0	49.7	50.9	2.8	1.6	47.7	0.0	0.0
AREA		0.0	0.0	0.0	0.0	0.0	13.9	14.8	3.1	1.1	10.0	0.0	0.0
HYD.RAD.		0.0	0.0	0.0	0.0	0.0	0.3	0.3	1.1	0.7	0.2	0.0	0.0
Q		0	0	0	0	0	0	20	15	0	11	0	0
STAGE:	38.05											
WET PER.		1.3	16.3	11.0	24.3	0.0	63.1	64.3	2.8	1.6	65.4	0.0	0.0
AREA		0.0	0.4	0.3	0.6	0.0	22.4	23.4	3.5	1.3	18.5	0.0	0.0
HYD.RAD.		0.0	0.0	0.0	0.0	0.0	0.4	0.4	1.3	0.8	0.3	0.0	0.0
Q		0	0	0	0	0	0	38	18	0	25	0	0
STAGE:	38.2											
WET PER.		5.0	65.0	44.0	97.3	0.0	76.4	77.6	2.8	1.6	83.1	0.0	0.0
AREA		0.5	6.5	4.4	9.7	0.0	32.8	34.0	4.0	1.5	29.6	0.0	0.0
HYD.RAD.		0.1	0.1	0.1	0.1	0.0	0.4	0.4	1.4	0.9	0.4	0.0	0.0
Q		0	4	0	7	0	0	62	22	0	47	0	0

W.S. Elev.	36.7	36.85	37	37.15	37.3	37.45	37.6	37.75	37.9	38.05	38.2
Q	0	0	1	3	5	7	13	25	46	81	142
A	0.0	0.2	0.7	1.3	1.9	3.2	7.0	15.1	28.0	46.5	83.8
V	0.0	0.8	1.5	2.0	2.4	2.3	1.8	1.6	1.7	1.7	1.7

31

WS Elev for 31 cfs = $(37.9-37.75)\left(\frac{31-25}{46-25}\right) + 37.75$

= 37.79

$V = 1.6 + (1.7-1.6)\left(\frac{31-25}{46-25}\right)$

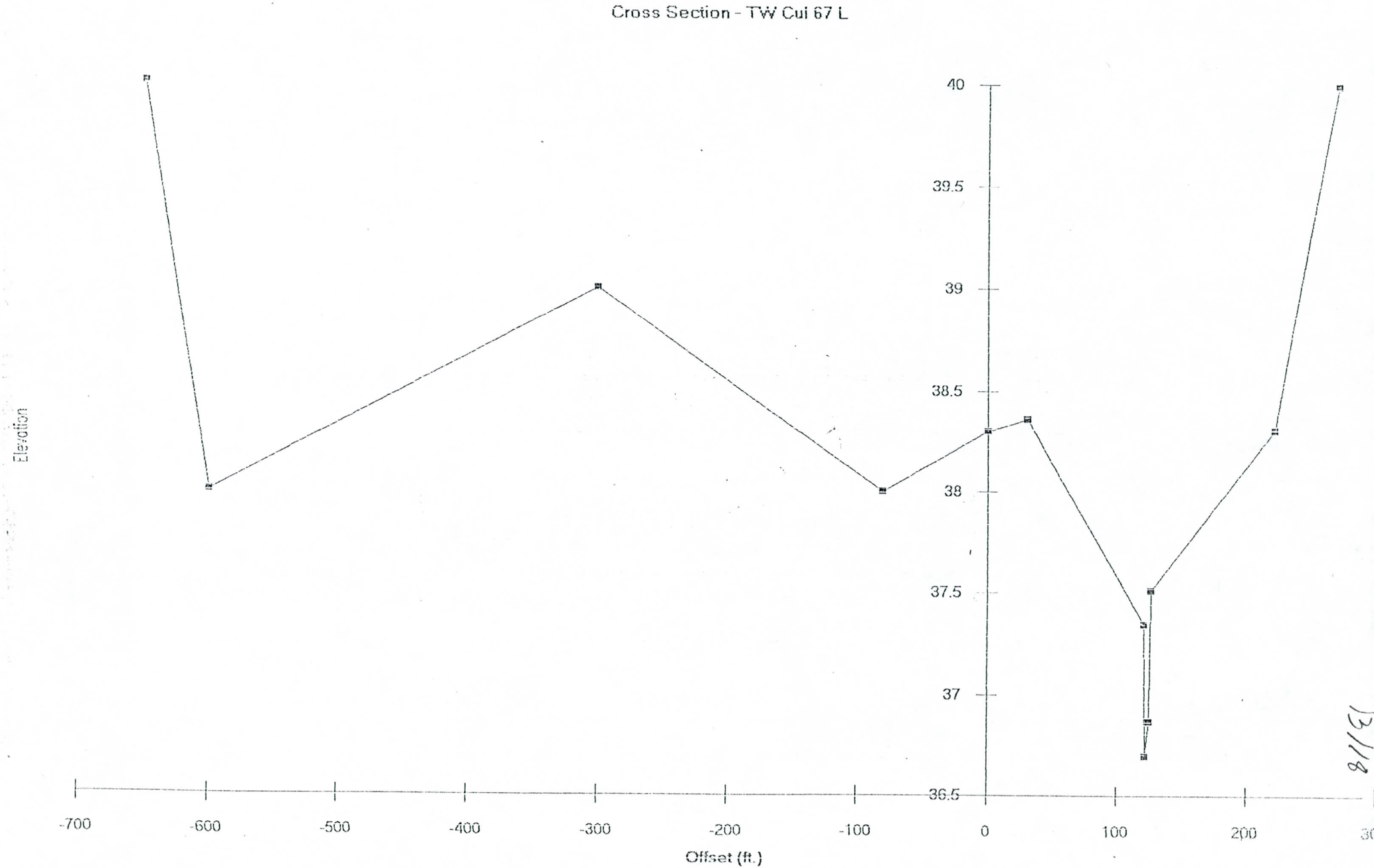
= 1.63 ft/s

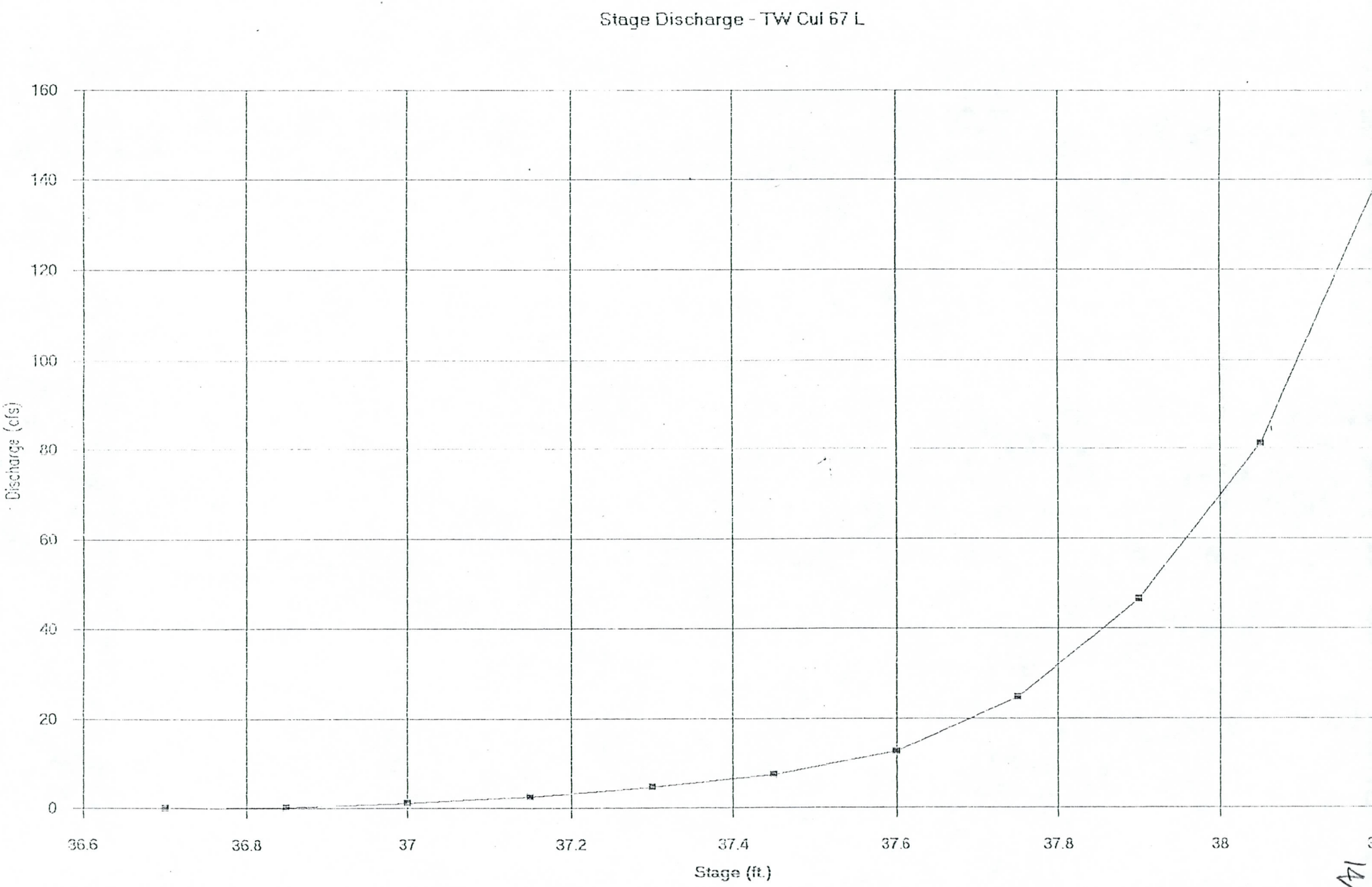
Tailwater depth =

37.79 − 36.70 =

1.09' ≈ 1.1'

8/12


Cross Section - TW Cul 67 L
Elevation
40
39.5
39
38.5
38
37.5
37
36.5
-700
-600
-500
-400
-300
-200
-100
0
100
200
Offset (ft.)


Stage Discharge - TW Cul 67 L
160
140
120
100
80
60
40
20
0
Discharge (cfs)
36.6
36.8
37
37.2
37.4
37.6
37.8
38
Stage (ft.)

SVERDRUP

JOB 40477 Toyota

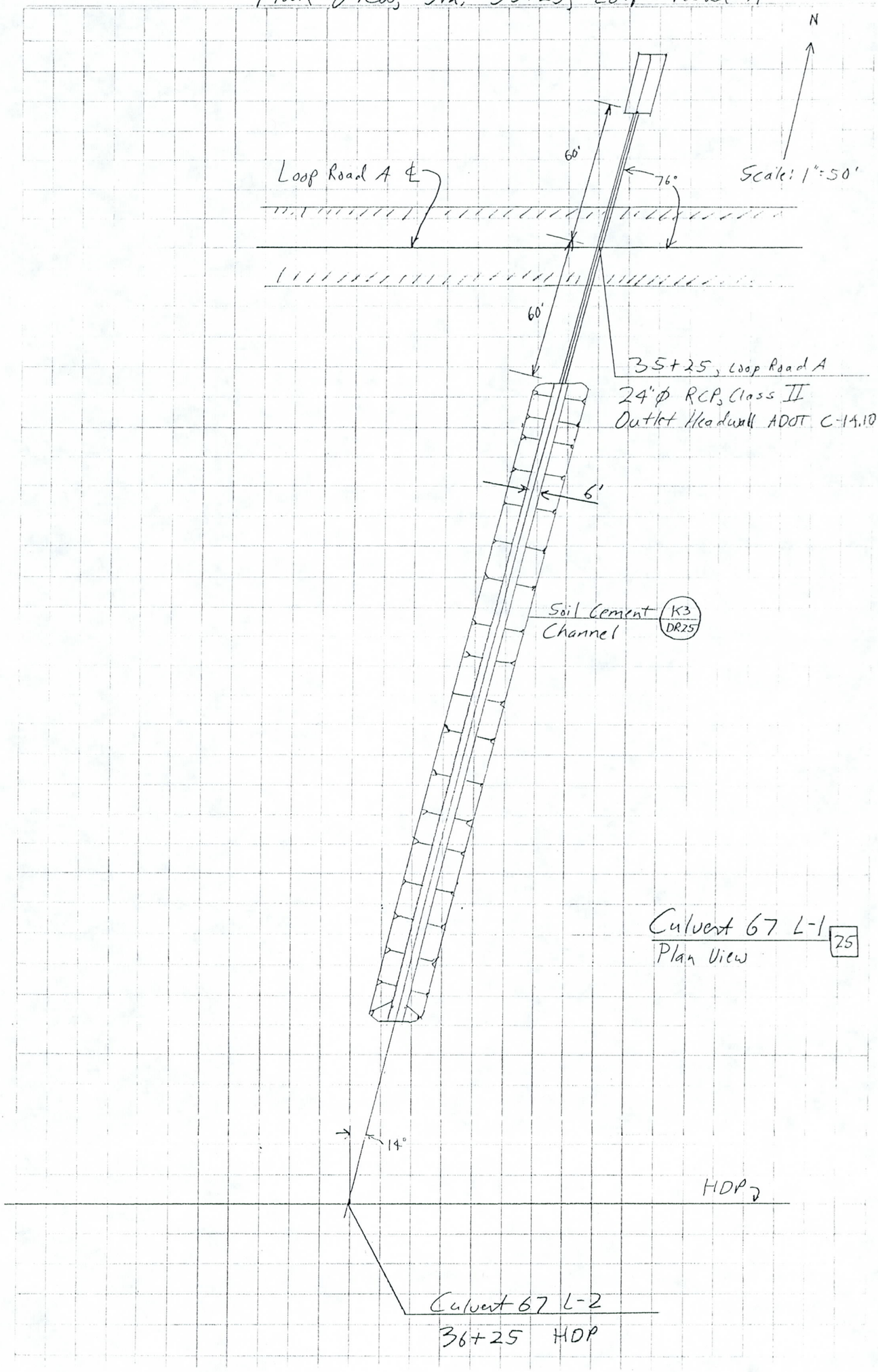
SHEET NO. 15 OF 18

DATE 8-19-91

COMPUTATIONS FOR Culvert 67 L-1 [25]

BY DFP CHKD RJT

Plan View, Sta. 35+25, Loop Road A



Culvert 67 L-1 [25]

Plan View

SVERDRUP

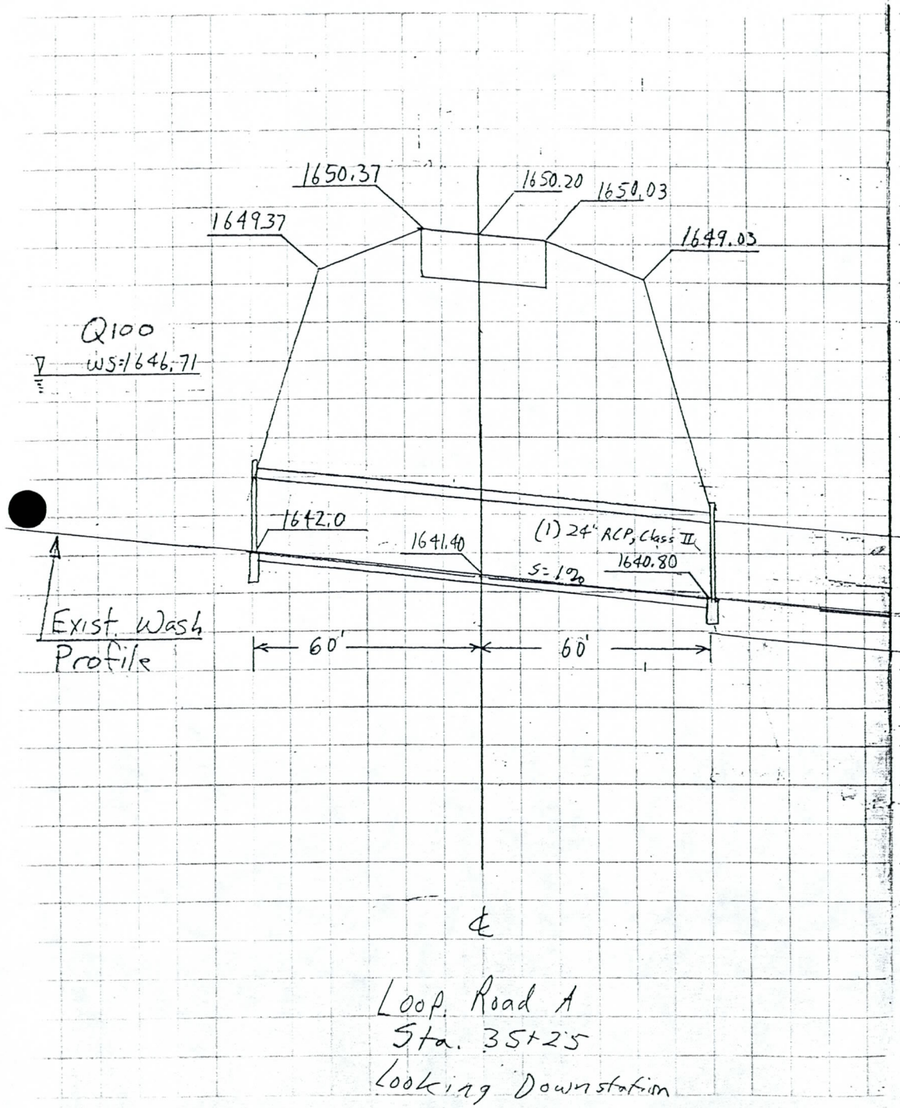
JOB 4077 Toyota

COMPUTATIONS FOR Culvert Profile 67 L-1 Loop Road A Sta. 35+25

DATE 7-5-91

BY DFP CHKD RVT

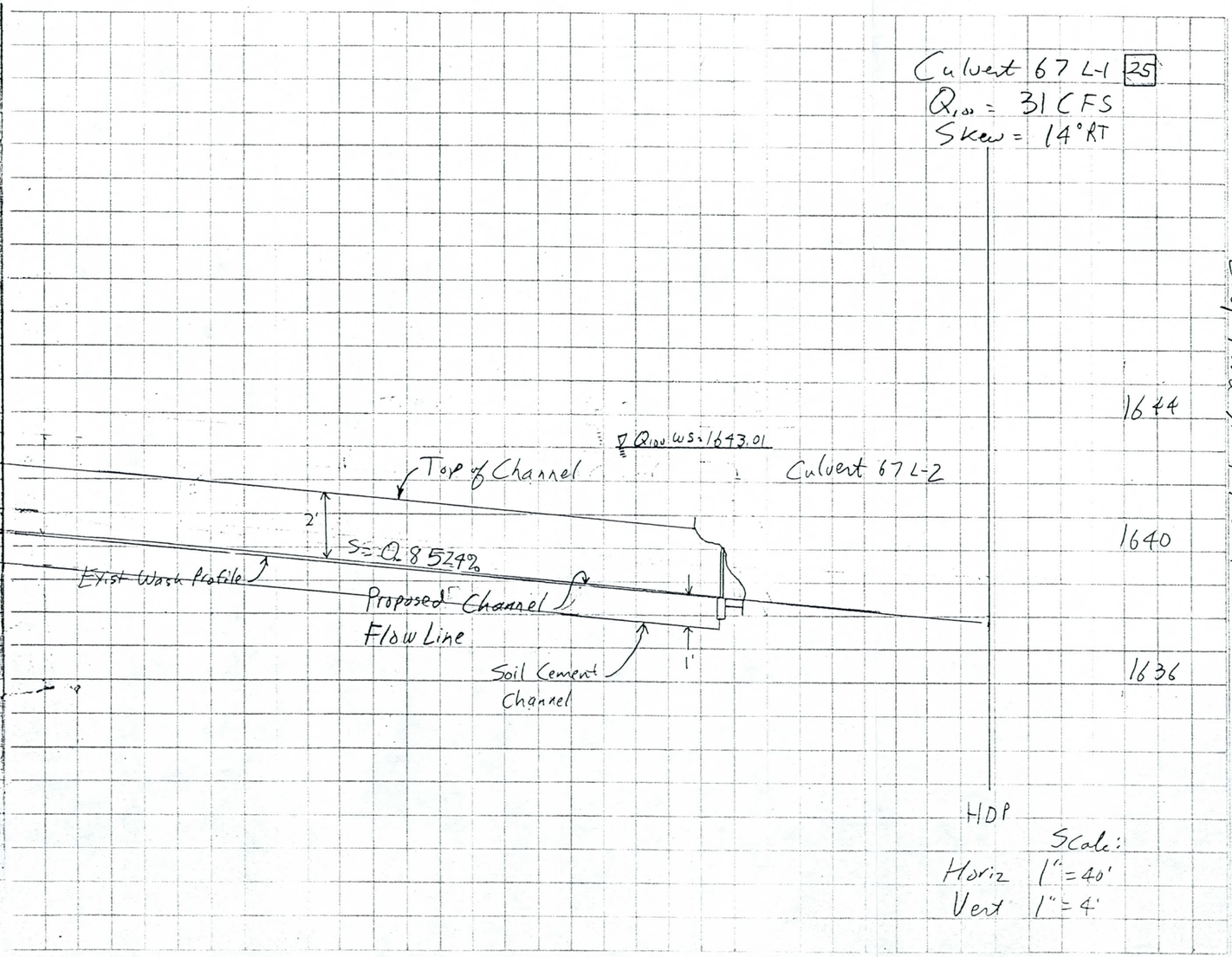
SHEET NO. 16 OF 18



&

Loop Road A
Sta. 35+25
Looking Downstation

Culvert 67 L-1 25
Q_{100} = 31 CFS
Skew = 14° RT



HDP

Scale:
Horiz 1"=40'
Vert 1"=4'

SVERDRUP

JOB 40477 Toyota

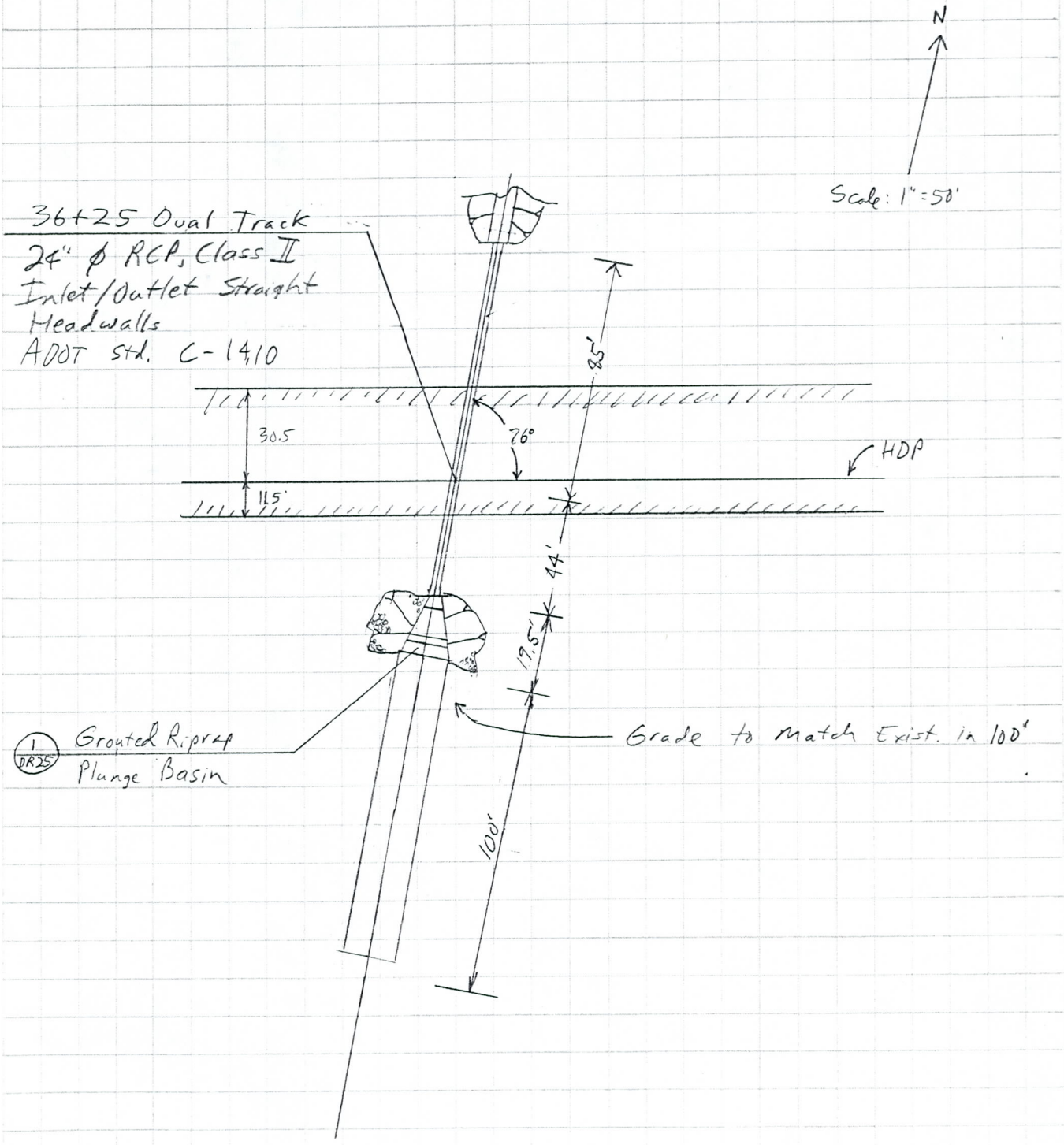
SHEET NO. 17 OF 18

DATE 8-19-91

COMPUTATIONS FOR Culvert 67 C-2 [26]

BY DFP CHKD RJT

Plan View HDP Sta. 36+25



SVERDRUP

JOB 4047 Toyota SHEET NO. 18 OF 18

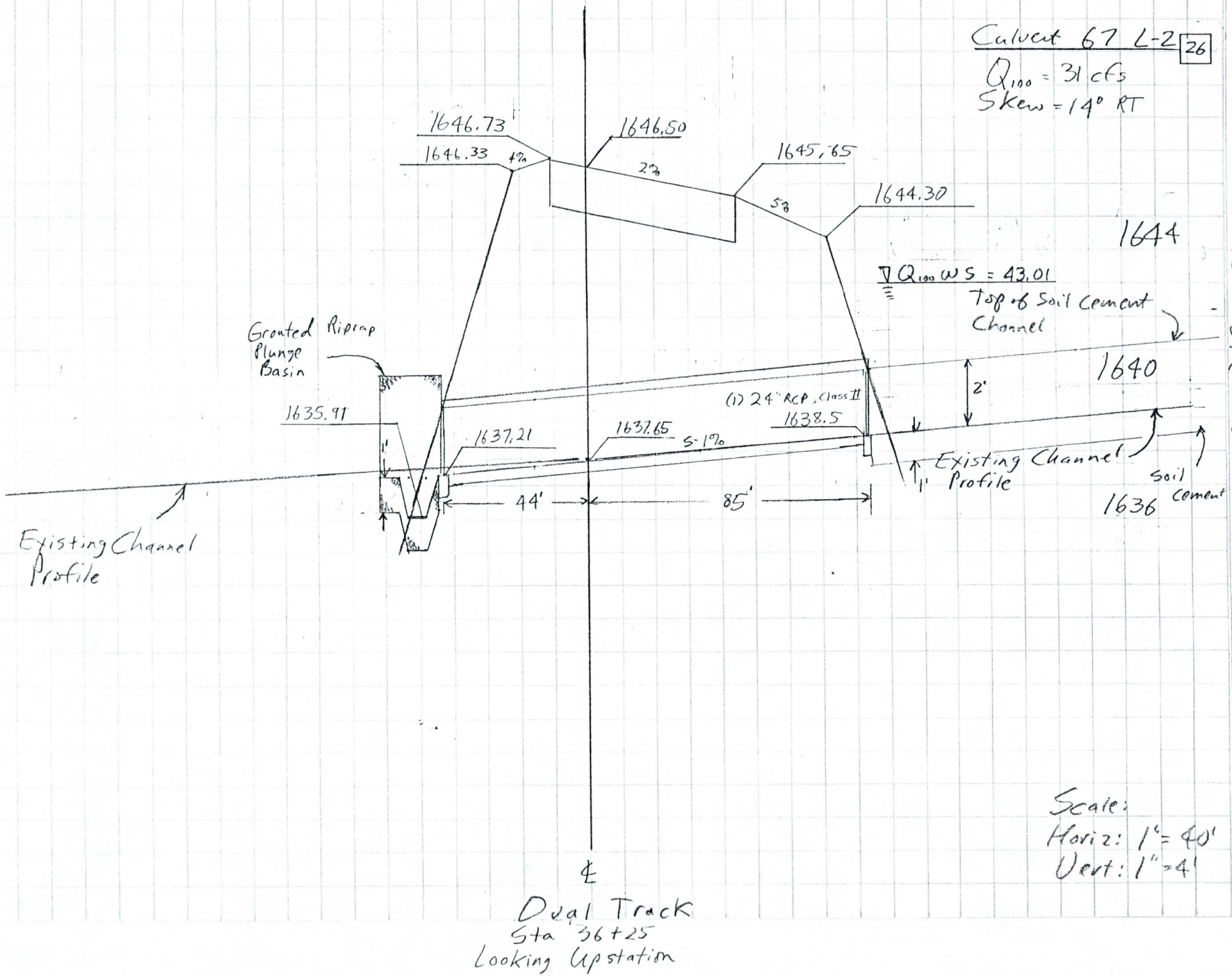
COMPUTATIONS FOR Culvert Profile 67 L-2 [26] DATE 6-17-91

HDP Sta 36+25 BY DFP CHKD RJT

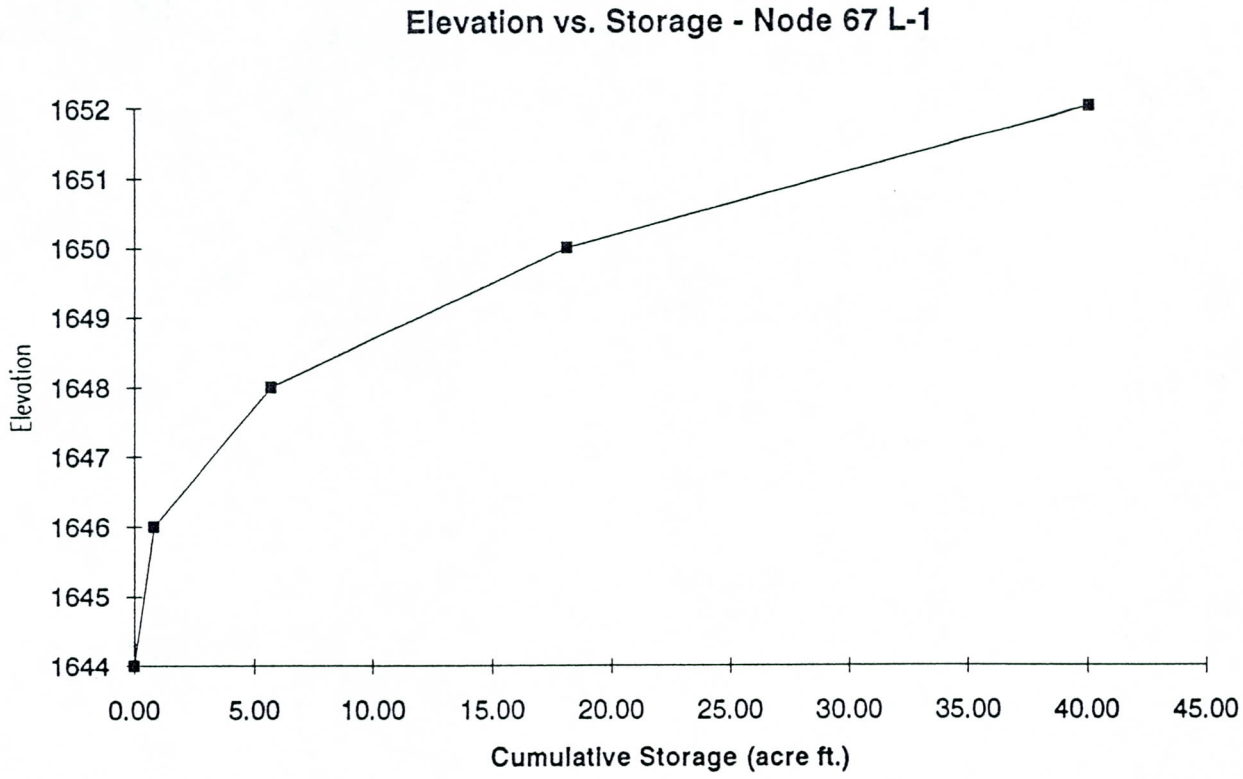
Culvert 67 L-2 [26]

Q_{100} = 31 cfs

Skew = 14° RT



Scale:
Horiz: 1" = 40'
Vert: 1" = 4'


Elevation vs. Storage - Node 67 L-1
1652
1651
1650
1649
1648
1647
1646
1645
1644
Elevation
0.00
5.00
10.00
15.00
20.00
25.00
30.00
35.00
40.00
45.00
Cumulative Storage (acre ft.)

SVERDRUP

JOB 40[redacted] Toyota SHEET NO. [redacted] OF

DATE 7-[redacted]-91

COMPUTATIONS FOR Proposed Culvert 70 Q-1 27 BY DFP CHKD RJT

CULVERT COMPUTATION SHEET

PROJECT:

STATION: 16+10 Loop Rd "A"

DESIGNER:

DATE:

HYDROLOGIC AND CHANNEL INFORMATION

DRAINAGE AREA

Q_1 = 1284 cfs

Q_2 =

TW_1 = 6.79 *

TW_2 =

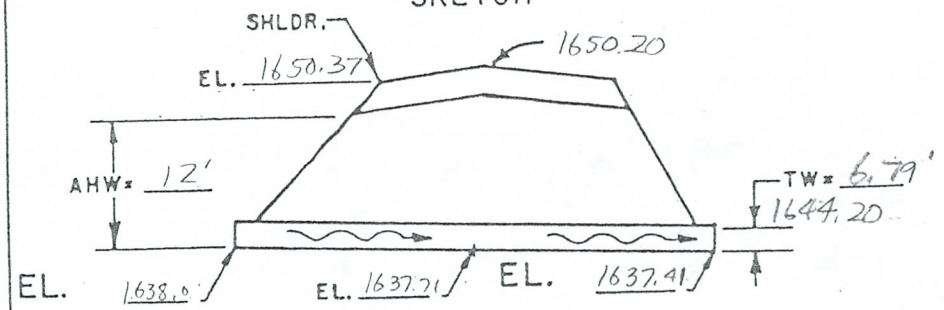
* Based upon DHWE of 1644.20 for Culvert 70 Q-2.

Peak Outlet Discharge Q_{100}

(Q_1 = DESIGN DISCHARGE, SAY Q_{25})

(Q_2 = CHECK DISCHARGE, SAY Q_{50})

SKETCH



S_0 = .005 L = 118' L/100 S_0 =

MEAN STREAM VELOCITY = 5.2 ft/s

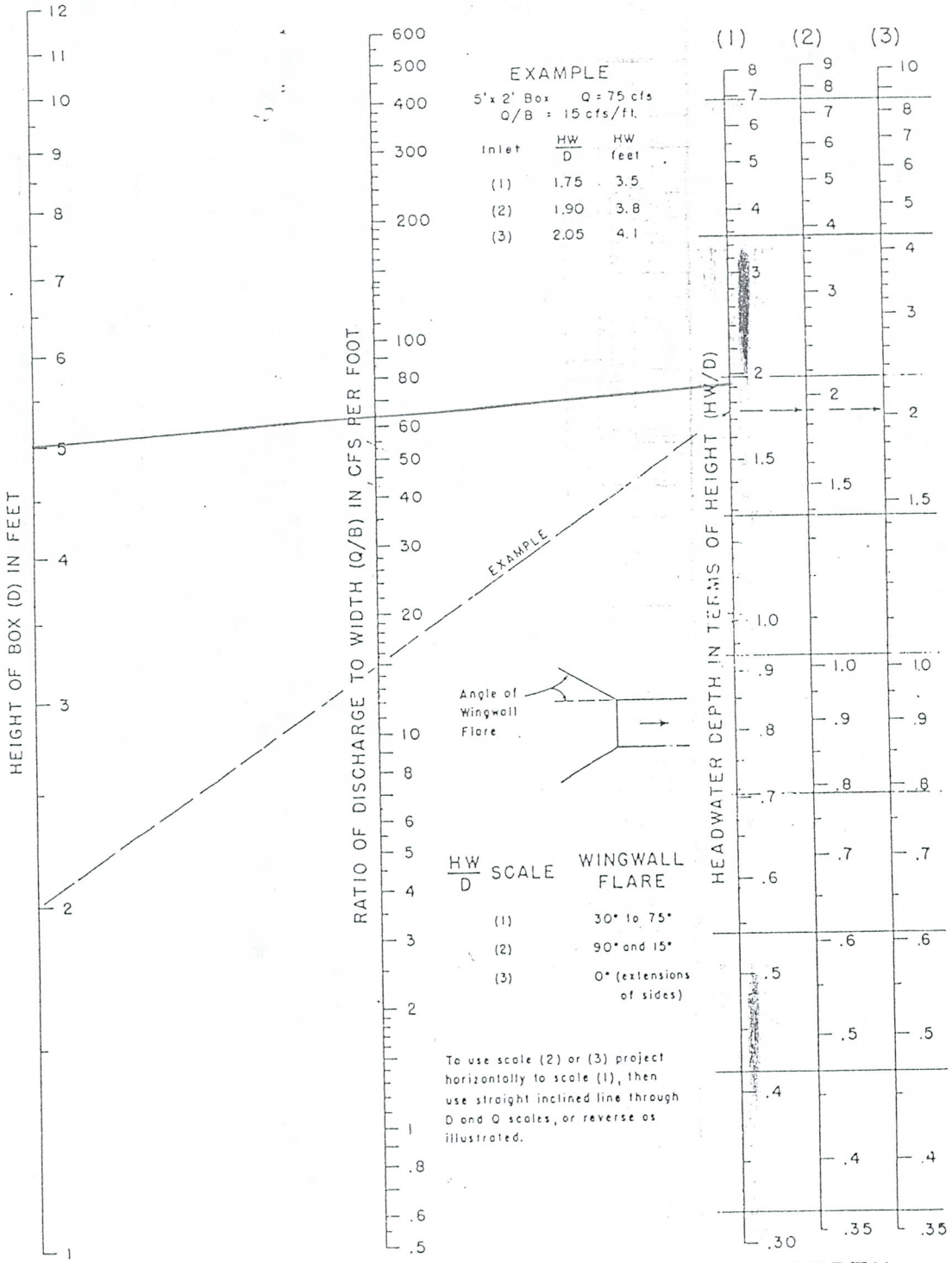
CULVERT DESCRIPTION		Q	CAP. CHART HW	HEADWATER COMPUTATION										CONTROL HW	OUTLET VELOCITY	COST	DHW ELEV.	COMMENTS
				INLET CONT.		OUTLET CONTROL $HW = H + h_o - LS_o$												
SIZE	ENTR. TYPE			$\frac{HW}{D}$	HW	K_e	H	d_c	$\frac{d_c + D}{2}$	TW	h_o	LS_o	HW					
2 Barrel 10'x5' RCBC	Drop	642		1.92	9.6	.2	3.8	5.0	5.0	6.79	6.79	.59	10.00	10.00	12.84**		1648.00	Outlet Control

SUMMARY & RECOMMENDATIONS ** $TW > d_c = D$ ∴ Culvert flowing full.

11/22

70 Q-1
2/22

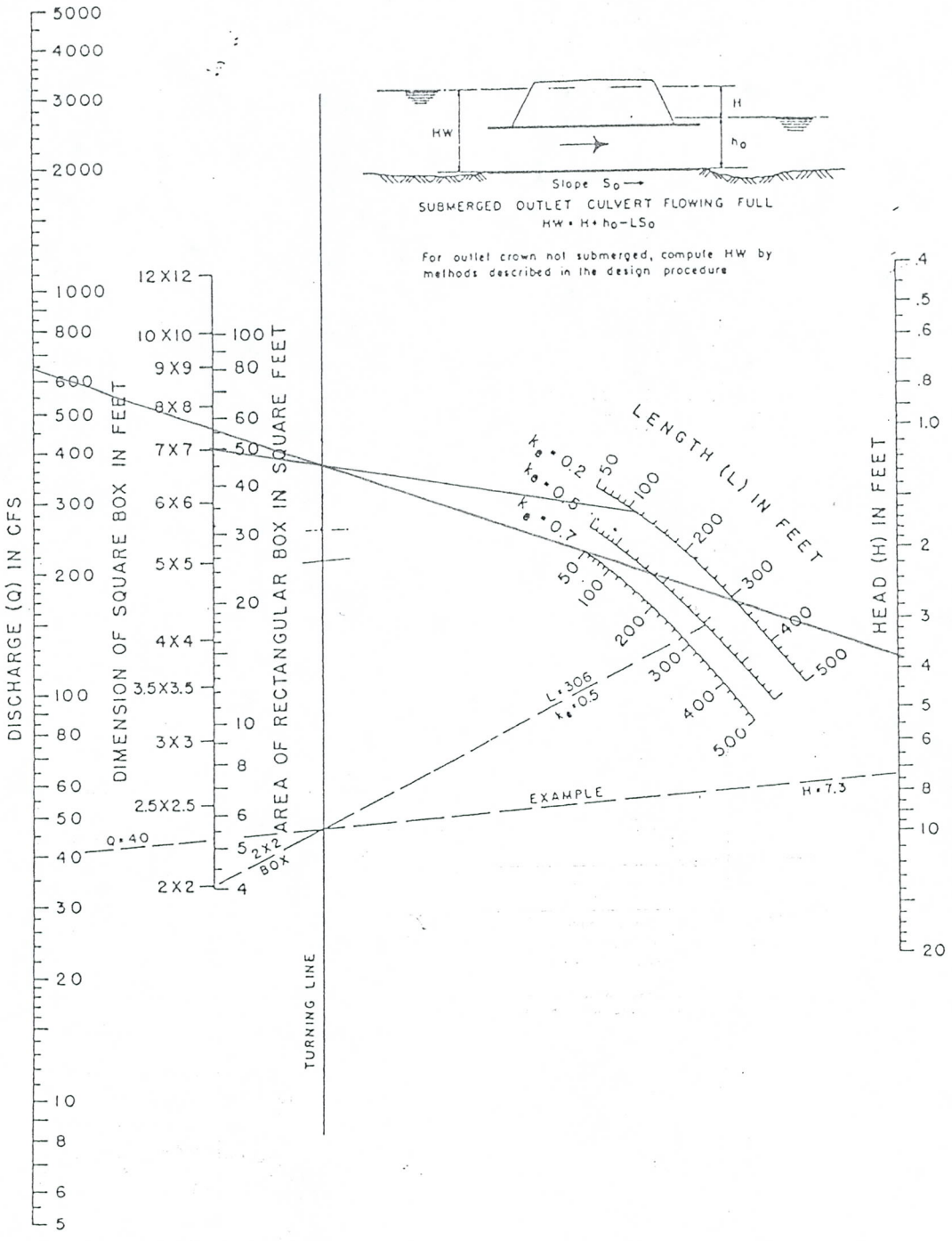
CHART I



HEADWATER DEPTH FOR BOX CULVERTS WITH INLET CONTROL

BUREAU OF PUBLIC ROADS JAN. 1963

CHART 8

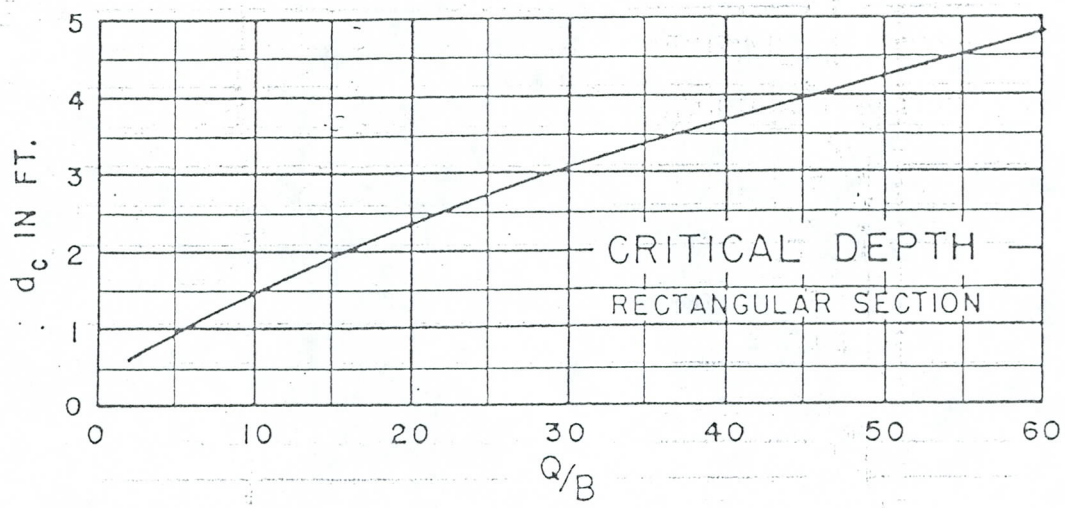


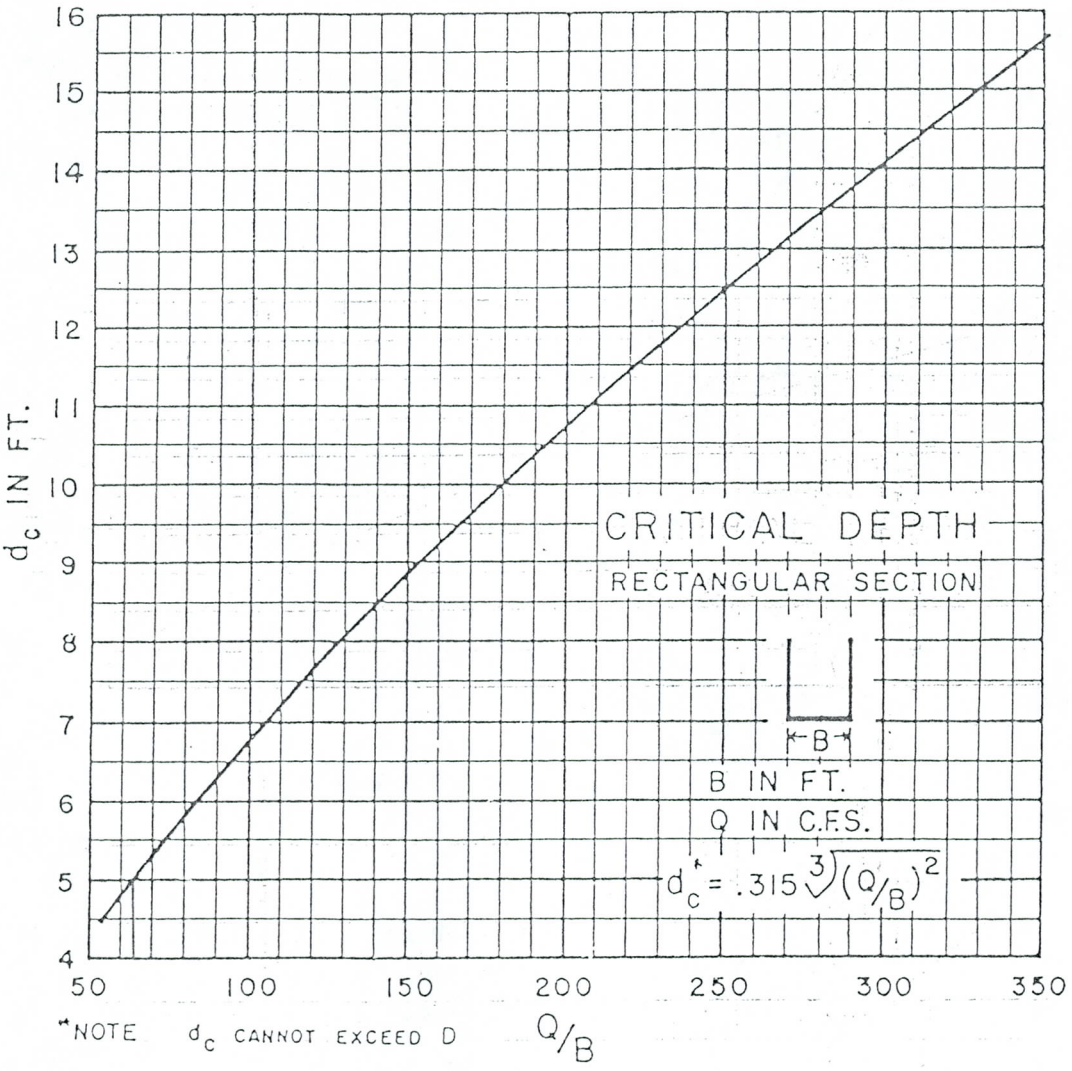
HEAD FOR
CONCRETE BOX CULVERTS
FLOWING FULL
n = 0.012

BUREAU OF PUBLIC ROADS JAN. 1963

4/22

CHART 15





*NOTE d_c CANNOT EXCEED D

BUREAU OF PUBLIC ROADS JAN 1963

SVERDRUP

JOB 4[redacted]7 Toyota

SHEET NO. [redacted] OF

DATE 7[redacted]2-91

COMPUTATIONS FOR Proposed Culvert 70Q-Z 28

BY DFP CHKD RJT

CULVERT COMPUTATION SHEET

PROJECT:

STATION: HDP Sta. 16+50

DESIGNER:

DATE:

HYDROLOGIC AND CHANNEL INFORMATION

DRAINAGE AREA

Q_1 = 1284 cfs

Q_2 =

TW_1 = 3.73*

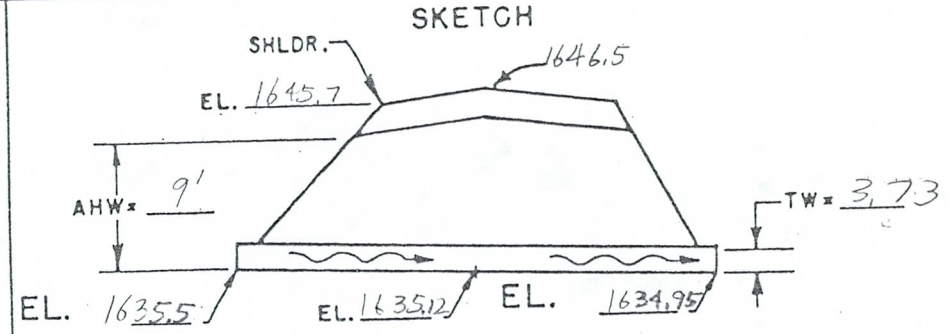
TW_2 =

Peak Outlet Discharge Q_{100}

(Q_1 = DESIGN DISCHARGE, SAY ~~Q_{25}~~)

(Q_2 = CHECK DISCHARGE, SAY Q_{50})

SKETCH



S_0 = .005

L = 111'

L/100 S_0 =

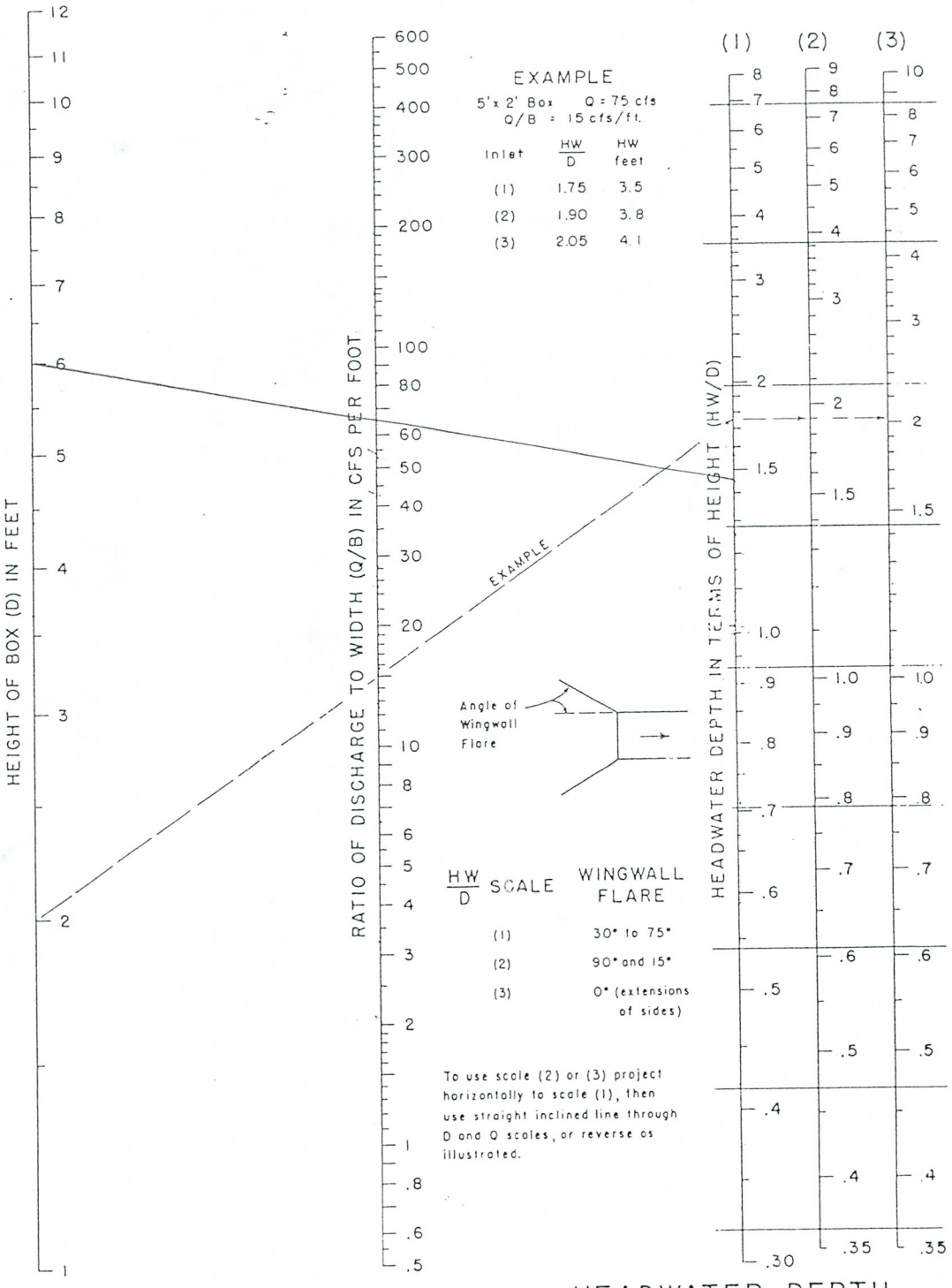
MEAN STREAM VELOCITY = 5.2 ft/s

CULVERT DESCRIPTION		Q	CAP. CHART HW	HEADWATER COMPUTATION											CONTROL HW	OUTLET VELOCITY	COST	DHW ELEV.	COMMENTS
				INLET CONT.		OUTLET CONTROL $HW = H + h_o - LS_o$													
SIZE	ENTR. TYPE			$\frac{HW}{D}$	HW	K_e	H	d_c	$\frac{d_c + D}{2}$	TW	h_o	LS_o	HW						
2 Barrel 10x6 RCBC	Wingwall	642		1.45	8.70	.2	2.5	5.0	5.5	3.73	5.5	.56	7.44		8.70	15.22		1644.20	Inlet Control

SUMMARY & RECOMMENDATIONS * From downstream existing channel calculations

5/22

CHART I

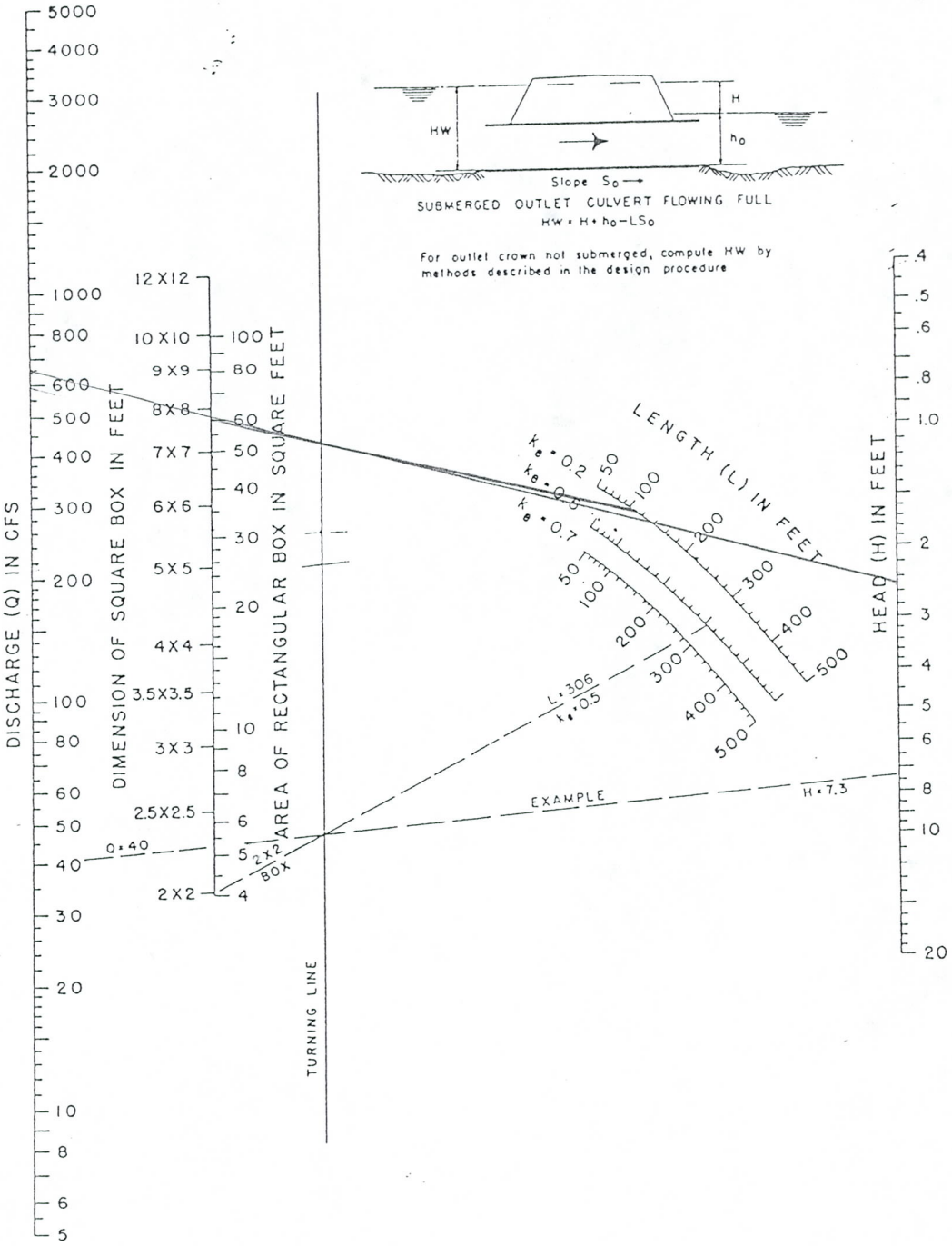


HEADWATER DEPTH FOR BOX CULVERTS WITH INLET CONTROL

BUREAU OF PUBLIC ROADS JAN. 1963

102-2
7/22

CHART 8

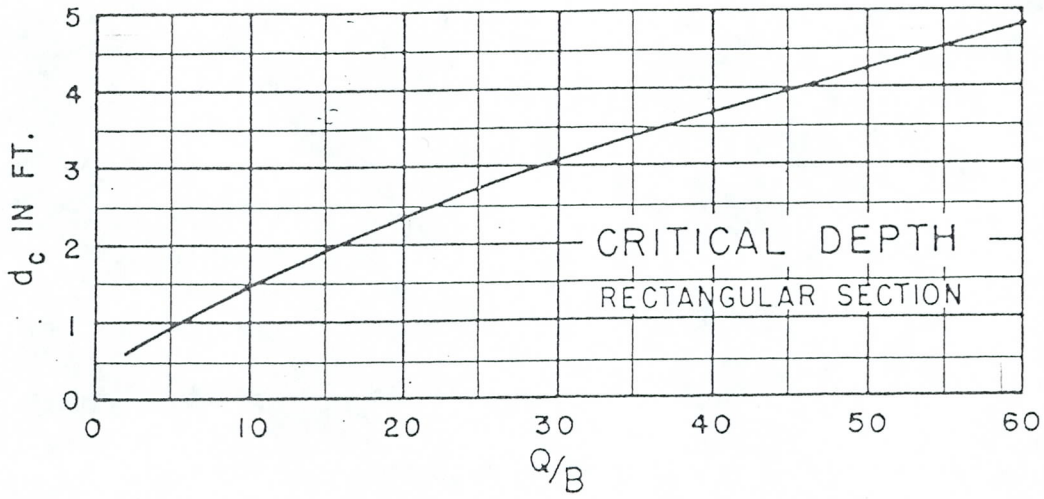


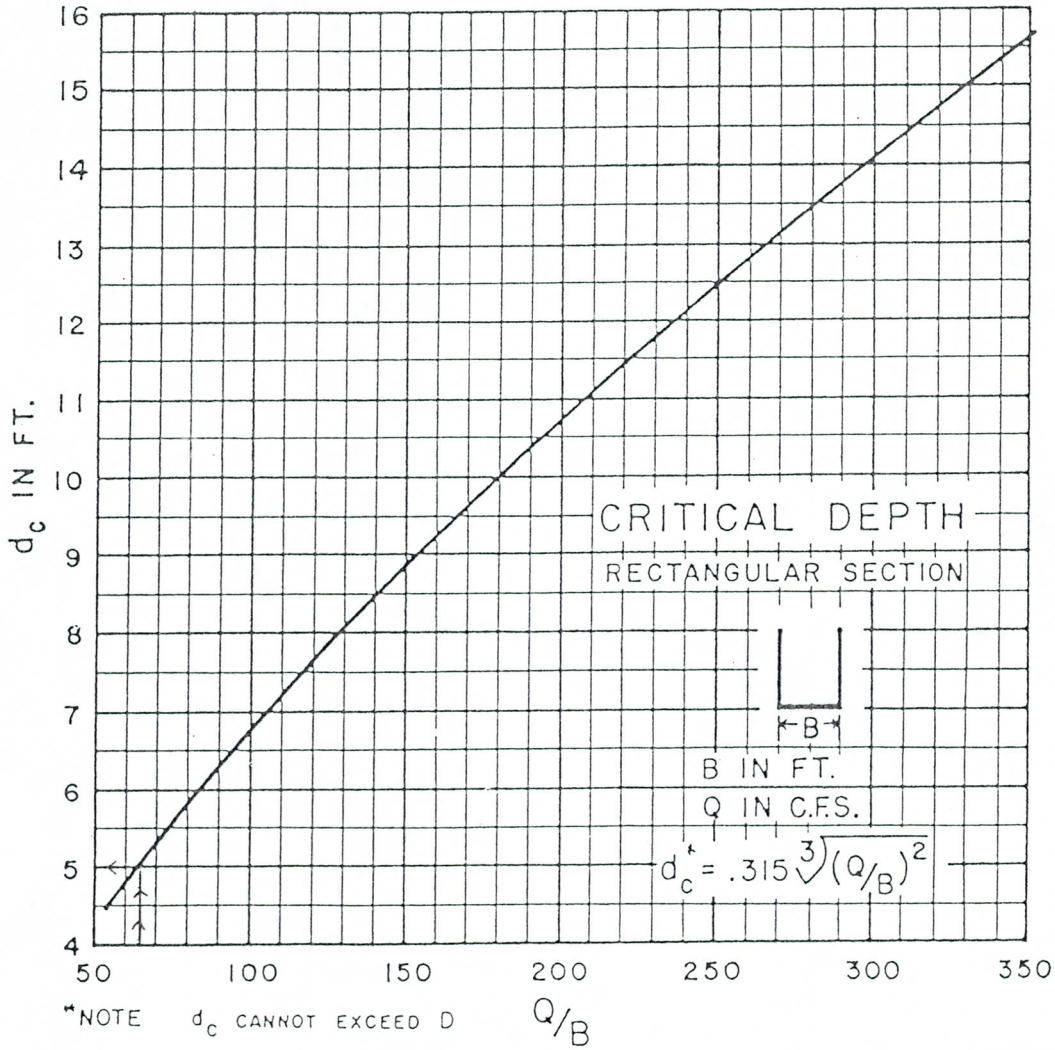
HEAD FOR CONCRETE BOX CULVERTS FLOWING FULL n = 0.012

BUREAU OF PUBLIC ROADS JAN. 1963

8/22

CHART 15





*NOTE d_c CANNOT EXCEED D

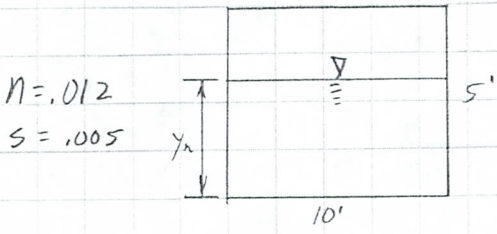
BUREAU OF PUBLIC ROADS JAN 1963

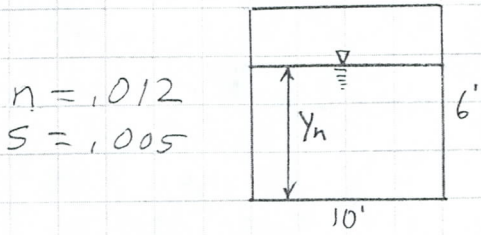
SVERDRUP

JOB 40477 Toyota SHEET NO. 9 OF 22

COMPUTATIONS FOR Culverts 70 Q-1 and 70 Q-2 BY DFP CHKD RJT DATE 7-4-91

Check Depth of flow in Culverts Using Manning's Formula:





Culvert 70 Q-1

$Q_{10} = 379 \Rightarrow 379/2 = 190$ cfs/barrel

$Q_{100} = 1284 \Rightarrow 1284/2 = 642$ cfs/barrel

For Q_{100}:

$y_n = 4.22'$

$V = 15.22$ ft/s

Check:

$Q = VA$

$= 15.22(4.22)10$

$= 642$ cfs OK

Froude Number: $N_F = \frac{V}{\sqrt{g\, y_n}}$

$N_F = \frac{15.22}{\sqrt{32.2(4.22)}}$ for Q_{100}

$= 1.31$ supercritical

Culvert 70 Q-2

$Q_{10} = 379 \Rightarrow 379/2 = 190$ cfs/barrel

$Q_{100} = 1284 \Rightarrow 1284/2 = 642$ cfs/barrel

For Q_{100}:

$y_n = 4.22$

$V = 15.22$

Check

$Q = VA$

$= 15.22(4.22)10$

$= 642$ cfs OK

$N_F = \frac{15.22}{\sqrt{32.2(4.22)}}$ for Q_{100}

$= 1.31$ supercritical

For Q_{10}:

$y_n = 1.80'$

$V = 10.56$ ft/s

$N_F = \frac{10.56}{\sqrt{32.2(1.80)}}$ for Q_{10}

$= 1.39$ supercritical

SVERDRUP

JOB 40477 Toyota SHEET NO. 10 OF 22

COMPUTATIONS FOR Culverts 70Q-1 and 70Q-2 DATE 7-4-91 BY DFP CHKD RJT

Channel Between Culverts 70 Q-1 and 70 Q-2

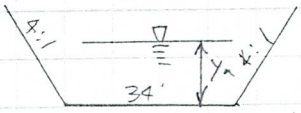
Analyze channel between 70Q-1 and 70 Q-2 - 34' Wide, 4:1 Side slopes, soil cement channel with constant slope between aprons.

$$S = \frac{1637.47 - .005(14.5) - (1635.5 + .005(9))}{\text{Cos}10(402.5) - 59 - 77 - 14.5 - 9} = \frac{1.7925}{249.21} = 0.007193$$

$n = .02$ $Q = 1284$ cfs

Mannings formula yields: $y_n = 2.72'$ $A = 121.83\ ft^2$

$V = 10.54$ ft/s $T = 55.76'$



$\frac{A}{T} = 2.18$

$$N_F = \frac{10.54}{\sqrt{32.2\ (2.18)}} = 1.26' \quad \text{Supercritical}$$

Determine Channel wall height:

Freeboard $= \frac{1}{6}\left(Y + \frac{V^2}{2g}\right) = \frac{1}{6}\left(2.72' + \frac{10.54^2}{2g}\right)$ where $N_F > .86$ & $y < 3$. ∴ Channel depth should be $2.72 + .74 = 3.46$. Use 3.5', Soil cement channel is to be used due to high velocity.

Channel Downstream of Culvert 70 Q-2:

Design earthen channel, bottom width = 60', 3:1 side slopes, downstream of plunge basin apron, channel height to match exist. ground.

From Mannings, where $S = 0.004$, $n = .03$ $Q = 1284$ cfs

$\Rightarrow y_n = 3.07'$, $A = 212.51\ ft^2$, $V = 6.04$ ft/s $T = 78.42'$

$$N_F = \frac{6.04}{\sqrt{32.2\ (\frac{A}{T})}} = 0.65 \quad \text{Subcritical}$$

$V = 6.04$ ft/s, which approaches exist. wash velocity of 5.2 ft/s.

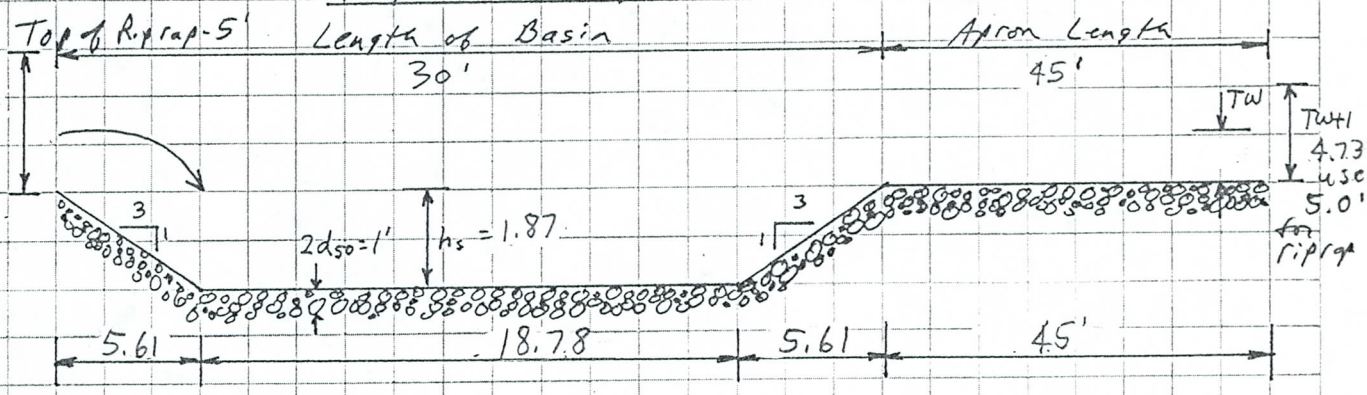
SVERDRUP

JOB 40477 Toyota SHEET NO. 11 OF 22

COMPUTATIONS FOR Box Culvert 70Q-2 DATE 7/23/91

BY DFP CHKD RJT

Riprap Plunge Basin Design (Q_{10})



Check Rock Size (From X1-2, HEC No. 14)

For $y_o = 1.80$ $d_{50} = 6"$ or $0.5'$

$d_{50}/y_o = .5/1.8 = .28$ N_F $1.39 < 3$ Plunge Basin OK

$h_s/y_o = 1.04$ $h_s = 1.8\,(1.04) = 1.87$

check $\frac{h_s}{d_{50}} = \frac{1.87}{.5} = 3.74$ < 4 but > 2 OK

Length of Basin:

$10\,h_s = 10\,(1.87) = 18.7'$

or

$3(W_o) = 3\,(10) = 30'$ Use 30'

Apron Length:

$5h_s = 5\,(1.8) = 9.0'$

$W_o = 10'$ use 10'

Riprap Height

Use TW+1 = 3.73+1 = 4.73

⇒ use 5'

$TW/y_o = \frac{3.73}{1.8} = 2.07$, > .75 ∴ downstream riprap req'd

70 Q-2
12/22

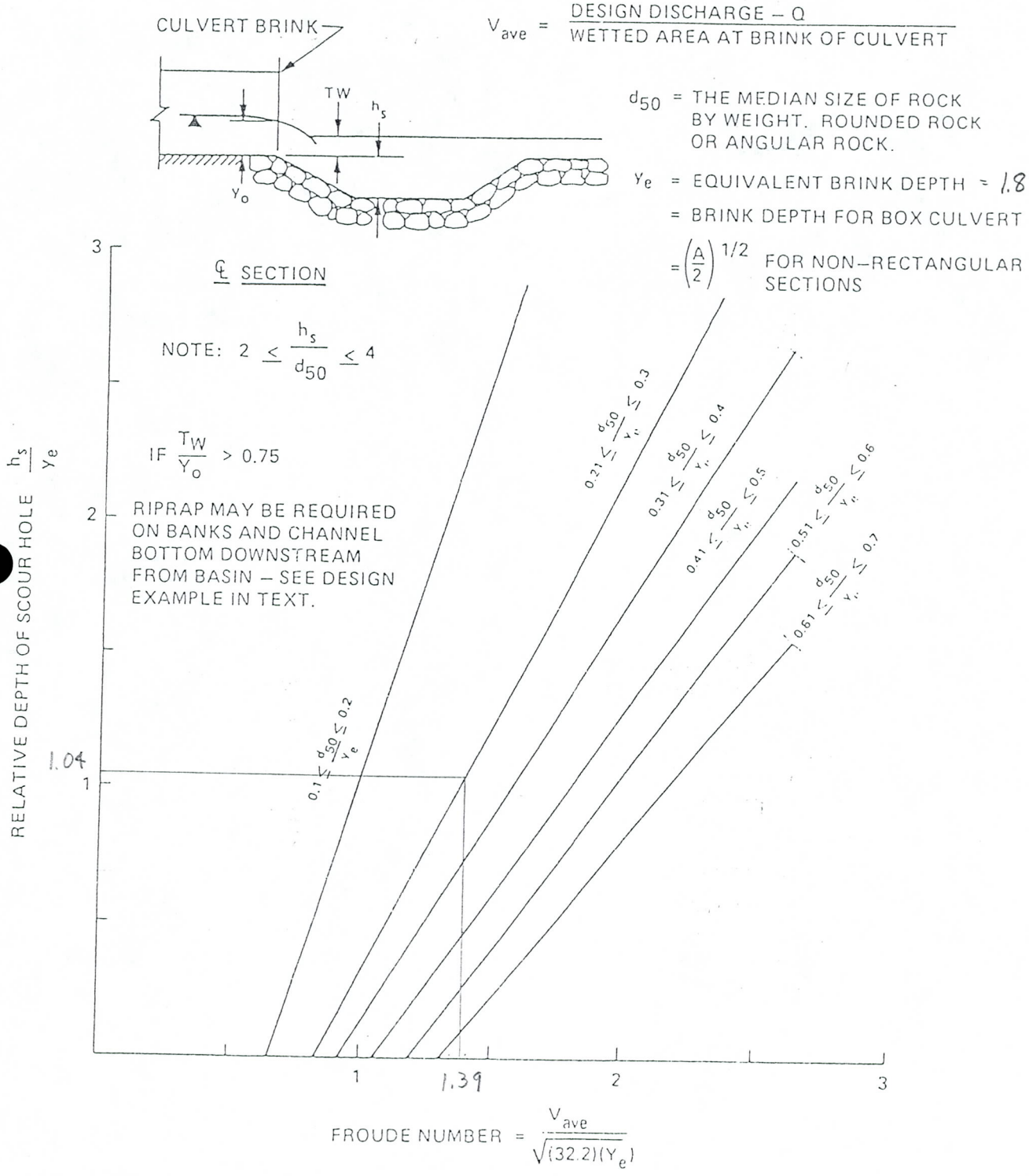


FIGURE X1–2. RELATIVE DEPTH OF SCOUR HOLE VERSUS FROUDE NUMBER AT BRINK OF CULVERT WITH RELATIVE SIZE OF RIPRAP AS A THIRD VARIABLE

SVERDRUP

JOB 40477 Toyota

COMPUTATIONS FOR Culvert 70 Q-2

SHEET NO. 13 OF 22

DATE 7-23-91

BY DFP CHKD RTT

Utilize figure XI-3 for existing average velocity along channel. Compute equivalent circular diameter, D_e, for brink area from:

$A = \pi D_e^2/4 = y_o (W_o) = 18 ft^2$ where $y_o = 1.8$ $W_o = 10'$

$D_e = \sqrt{A(4)/\pi} = 4.79'$

From Downstream cross section calculation sheets, Q_{10} velocity is 4.10 ft/s. Culvert outlet velocity = 10.56 ft/s.

L/D_e	L	V_L/V_o	V_L
15.5	74.2	.39	4.1 ft/s OK

Need riprap lining for approximately 75'. Since the basin itself is 30', the apron length is 75' - 30' = 45'

Slope apron @ S = .005, starting at downstream end of basin

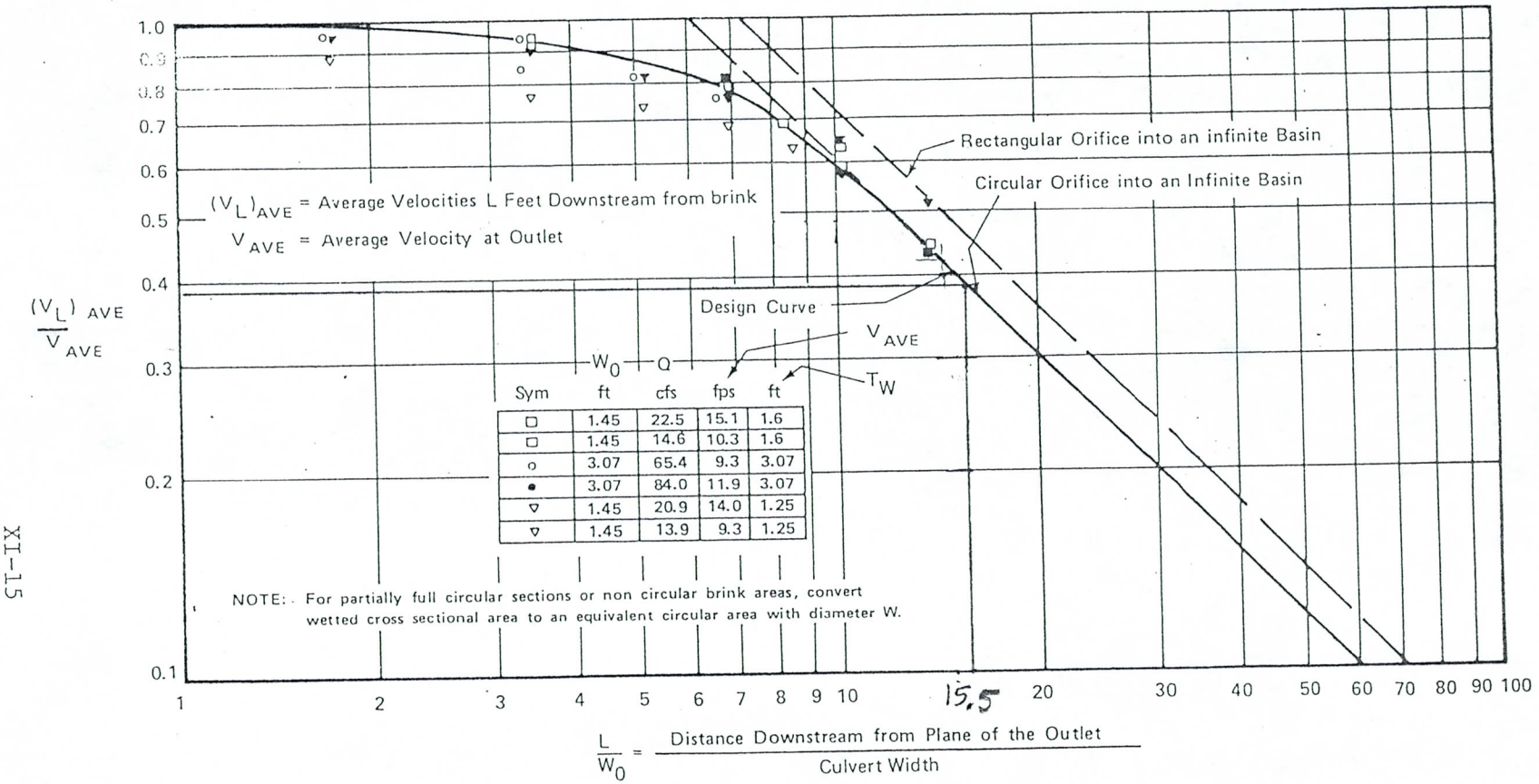


Figure XI - 3 Distribution of Centerline Velocity for Flow from Submerged Outlets from Reference XI - 2. to be used for Predicting Channel Velocities Downstream from Culvert Outlet where High Tailwater prevails. Velocities obtained from the use of this Chart can be used with Figure 2 of HEC No. 11 for sizing riprap (DO not use Figure 1 HEC No. 11, use Mean Velocity Values)

14/22

SVERDRUP

JOB 40477 Toyota

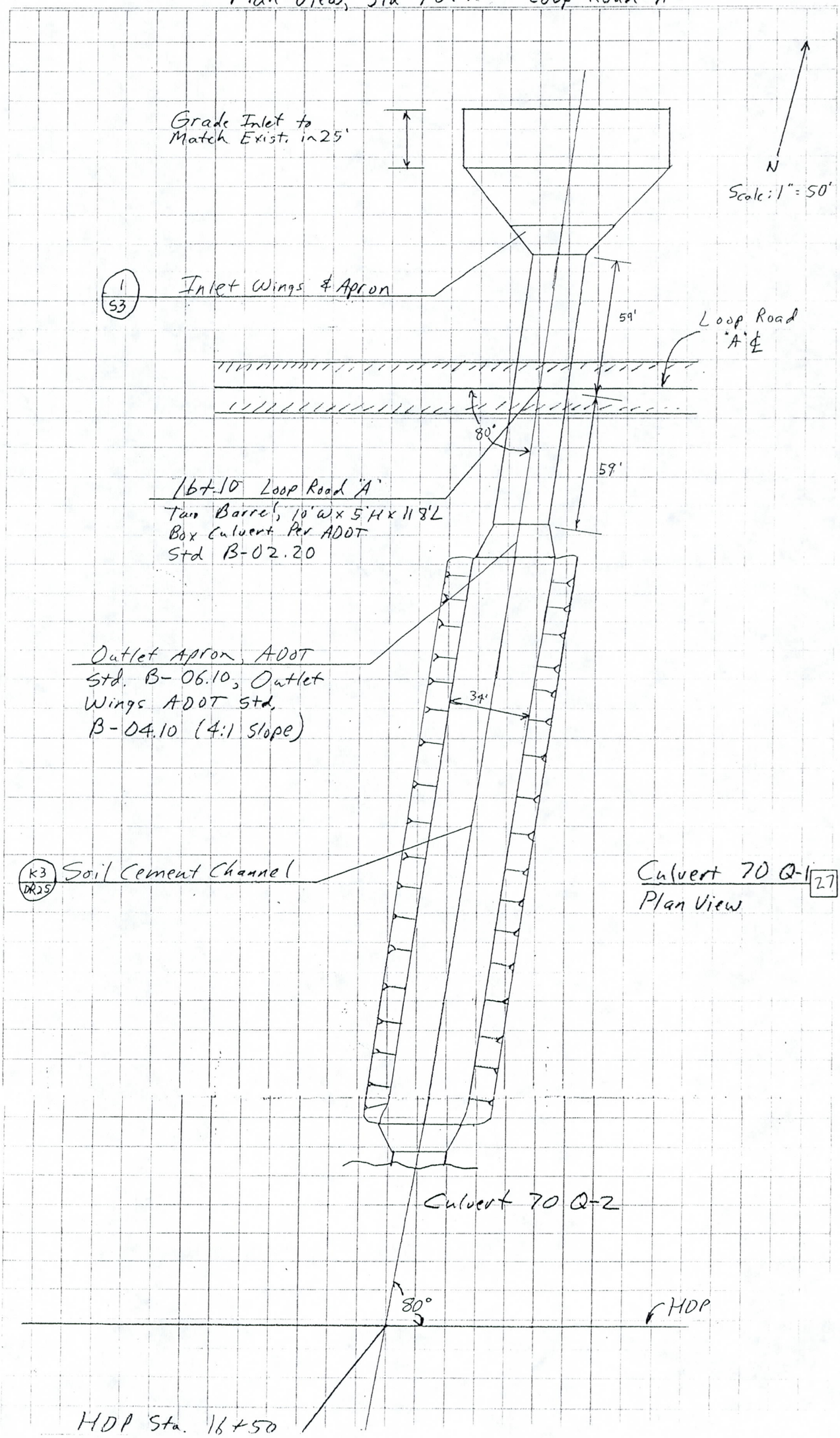
SHEET NO. 15 OF 22

DATE 7-12-91

COMPUTATIONS FOR Culvert 70 Q-1 [27]

BY DFP CHKD RJT

Plan View, Sta 16+10 Loop Road "A"



Culvert 70 Q-1 [27]

Plan View

SVERDRUP

JOB 40477 Toyota

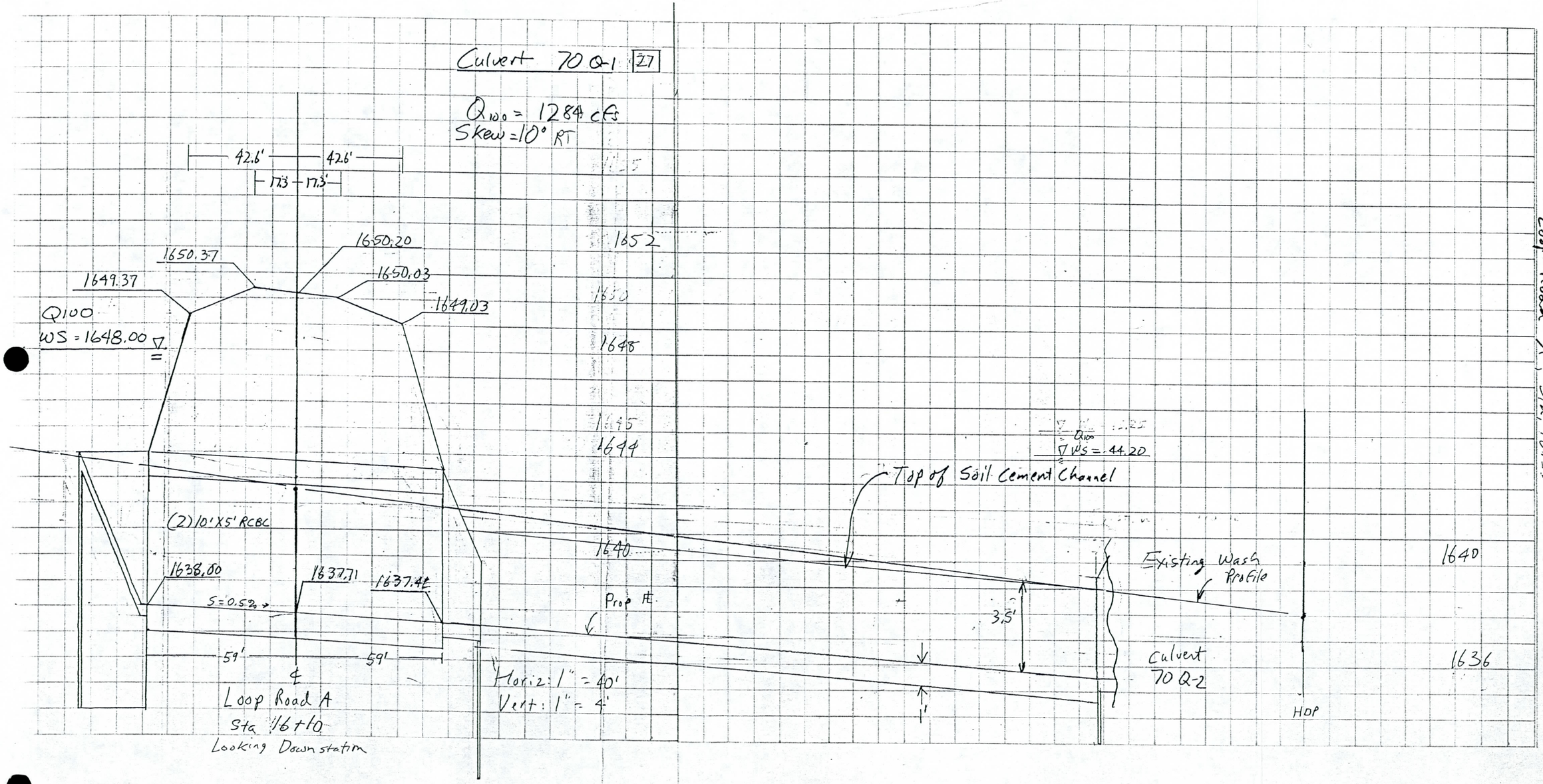
COMPUTATIONS FOR Culvert Profile 70 Q-1 [27]
Loop Road "A" Sta. 16+10

DATE 7-4-91 BY DFD CHKD RJT

SHEET NO. 16 OF 22

Culvert 70 Q-1 [27]

Q_{100} = 1284 cfs
Skew = 10° RT



SVERDRUP

JOB 40477 Toyota

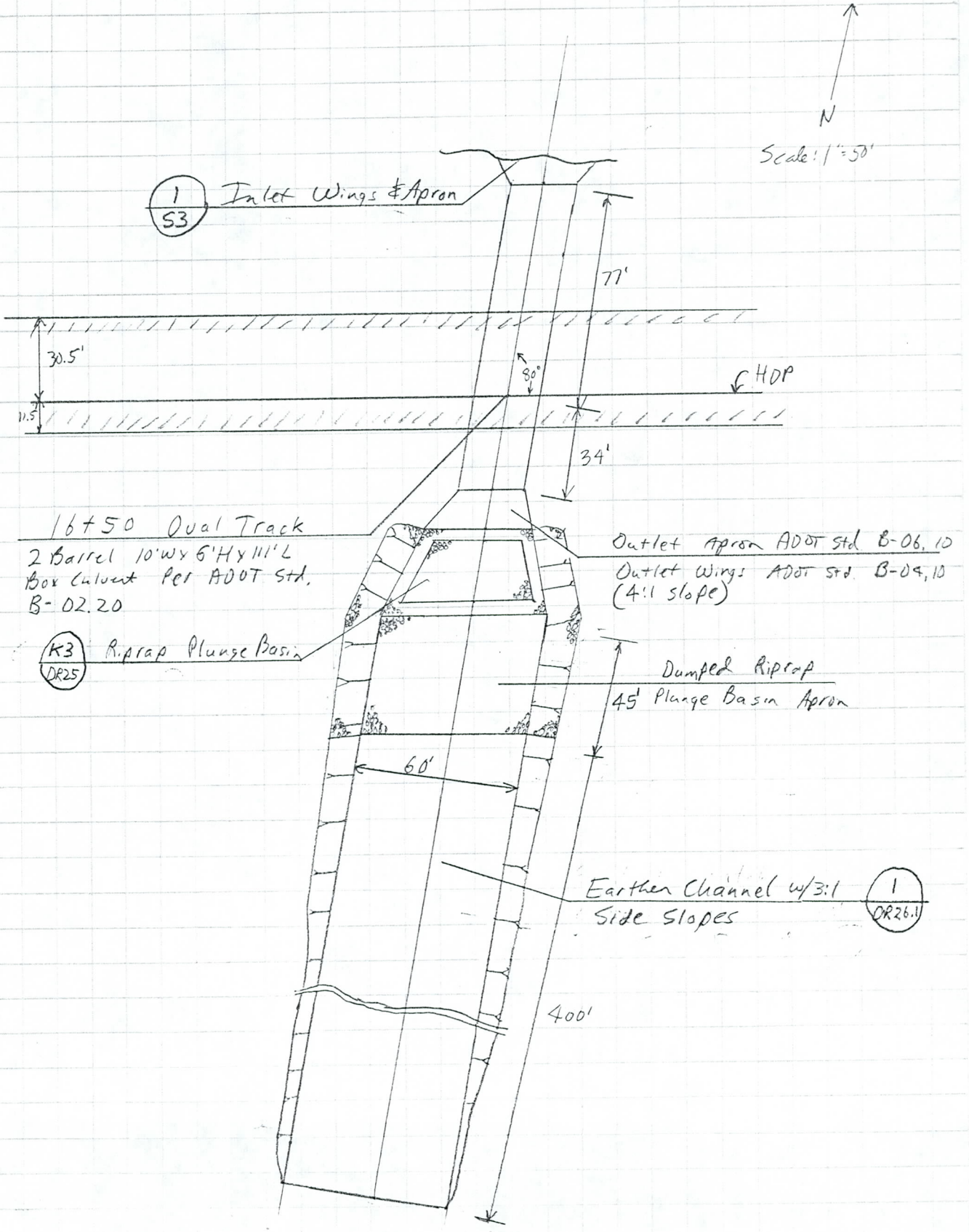
SHEET NO. 17 OF 22

DATE 7-12-91

COMPUTATIONS FOR Culvert 70 Q-2 [28]

BY DFP CHKD RVT

Plan View HDP Sta 16+50



SVERDRUP

JOB 40477 Toyota

COMPUTATIONS FOR Culvert Profile 70 Q-2 28

HDP Sta. 16+50

DATE 6-30-91 BY DFP CHKD RVT

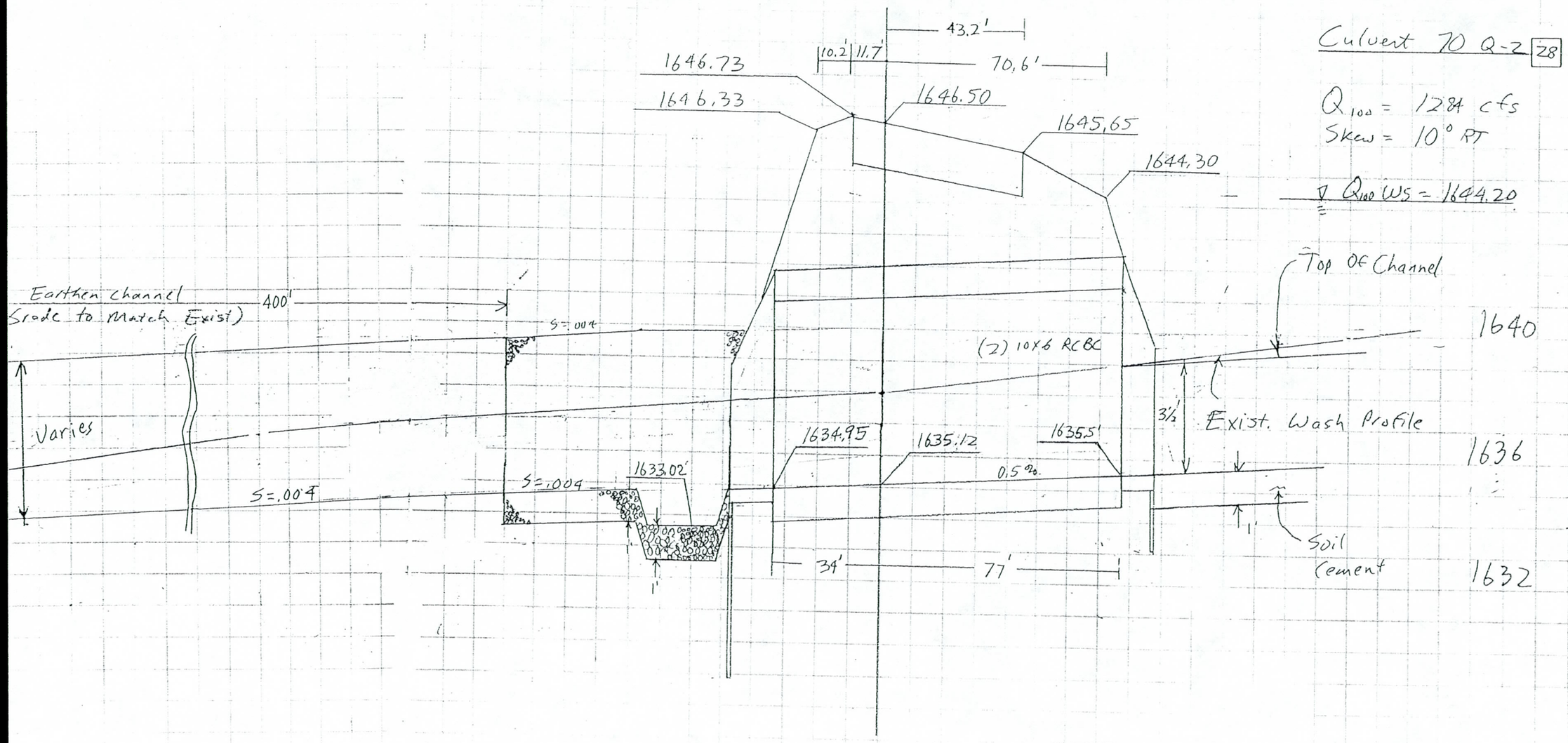
SHEET NO. 18 OF 22

Culvert 70 Q-2 28

Q_{100} = 1284 cfs

Skew = 10° RT

Q_{100} WS = 1644.20



℄

Oval Track

Sta. 16+50

Looking Upstation

Scale:

Horiz: 1" = 40'

Vert: 1" = 4'

SECTION NUMBER TW70Q 6/10/91

Channel Slope: 0.0093 ft./ft.

CROSS SECTION DATA:

OFFSET	-155	48.1	126.2	130.5	132.4	136.1	149.9	153.8	160	162.7	198.7	235.1
ELEV.	42	40.08	38.22	36.73	36.5	38.35	36.49	37.85	37.58	38.5	39.32	41.02
N	N/A	0.035	0.035	0.035	0.025	0.035	0.035	0.035	0.035	0.035	0.035	0.035

STAGE-DISCHARGE DATA:

STAGE:	36.5											
WET PER.		0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0
AREA		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYD.RAD.		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Q		0	0	0	0	0	0	0	0	0	0	0	0
STAGE:	36.9												
WET PER.		0.0	0.0	0.5	1.9	0.9	3.1	4.3	0.0	0.0	0.0	0.0	0.0
AREA		0.0	0.0	0.0	0.5	0.2	0.6	0.9	0.0	0.0	0.0	0.0	0.0
HYD.RAD.		0.0	0.0	0.1	0.3	0.2	0.2	0.2	0.0	0.0	0.0	0.0	0.0
Q		0	0	0	1	0	0	1	0	0	0	0	0
STAGE:	37.3												
WET PER.		0.0	0.0	1.7	1.9	1.8	6.1	8.5	0.0	0.0	0.0	0.0	0.0
AREA		0.0	0.0	0.5	1.3	0.6	2.4	3.4	0.0	0.0	0.0	0.0	0.0
HYD.RAD.		0.0	0.0	0.3	0.7	0.4	0.4	0.4	0.0	0.0	0.0	0.0	0.0
Q		0	0	1	6	1	0	7	0	0	0	0	0
STAGE:	37.7												
WET PER.		0.0	0.0	3.0	1.9	2.7	9.1	12.7	2.8	3.1	0.0	0.0	0.0
AREA		0.0	0.0	1.4	2.1	1.4	5.4	7.5	0.2	0.2	0.0	0.0	0.0
HYD.RAD.		0.0	0.0	0.5	1.1	0.5	0.6	0.6	0.1	0.1	0.0	0.0	0.0
Q		0	0	3	12	4	0	22	0	0	0	0	0
STAGE:	38.1												
WET PER.		0.0	0.0	4.2	1.9	3.6	12.1	16.2	22.4	24.0	0.0	0.0	0.0
AREA		0.0	0.0	2.7	2.8	2.6	9.6	13.2	15.6	16.0	0.0	0.0	0.0
HYD.RAD.		0.0	0.0	0.6	1.5	0.7	0.8	0.8	0.7	0.7	0.0	0.0	0.0
Q		0	0	8	21	8	0	0	0	50	0	0	0
STAGE:	38.5												
WET PER.		0.0	11.8	16.3	1.9	4.1	18.1	20.2	28.4	31.3	0.0	0.0	0.0
AREA		0.0	1.6	6.1	3.6	4.0	18.9	24.1	28.9	30.2	0.0	0.0	0.0
HYD.RAD.		0.0	0.1	0.4	1.9	1.0	1.0	1.1	1.0	1.0	0.0	0.0	0.0
Q		0	0	13	31	0	0	0	0	120	0	0	0

1/22

SECTION NUMBER TW70Q 6/10/91

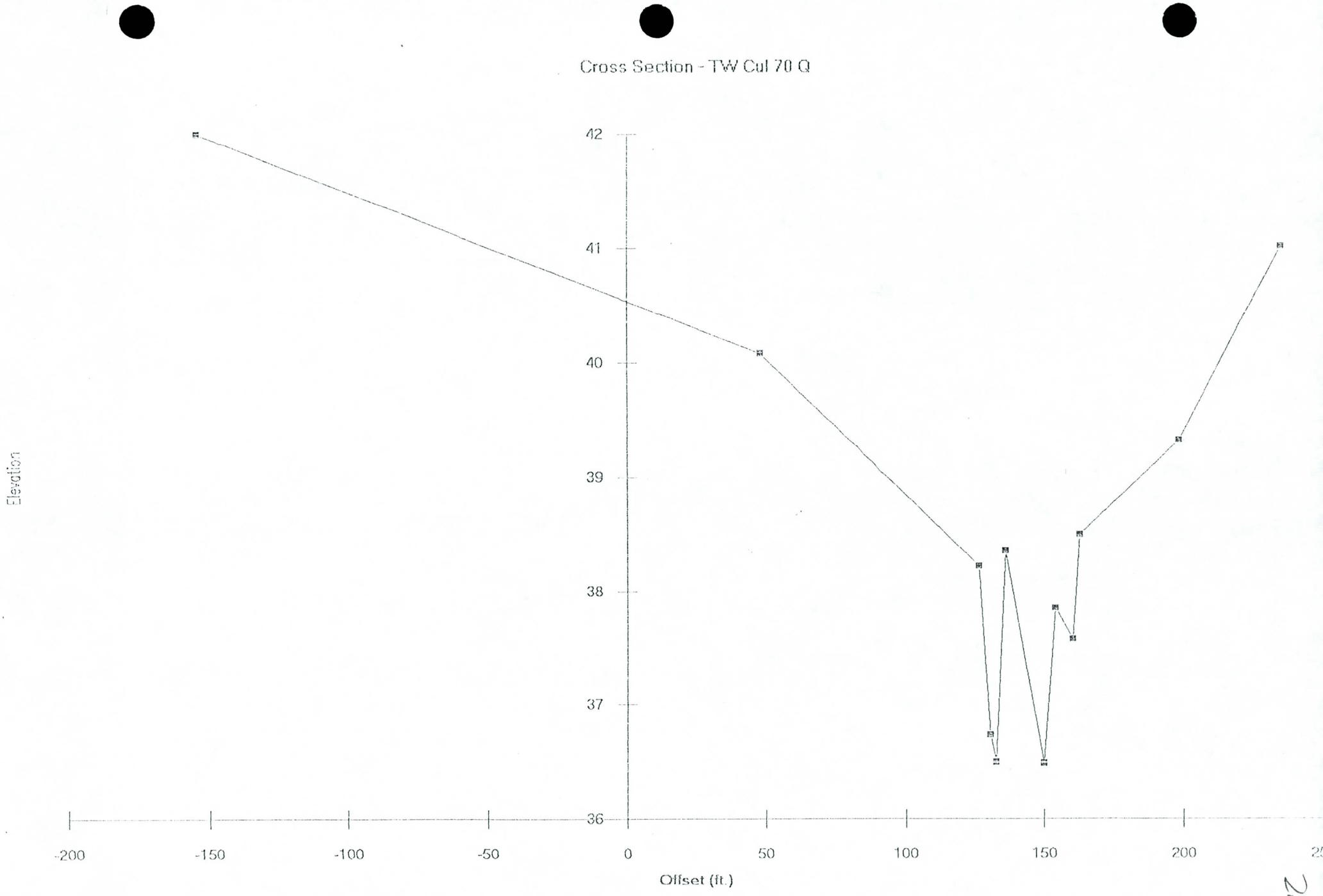
STAGE:	38.9											
WET PER.		0.0	28.6	33.1	1.9	4.1	18.1	22.2	28.4	31.3	48.8	0.0	0.0
AREA		0.0	9.7	15.8	4.3	5.5	25.9	32.6	40.0	42.3	45.8	0.0	0.0
HYD.RAD.		0.0	0.3	0.5	2.3	1.3	1.4	1.5	1.4	1.4	0.9	0.0	0.0
Q		0	0	40	43	0	0	0	0	0	179	0	0
STAGE:	39.3												
WET PER.		0.0	45.4	49.9	1.9	4.1	18.1	22.2	28.4	31.3	66.4	0.0	0.0
AREA		0.0	24.5	32.3	5.1	6.9	32.9	41.2	51.0	54.4	68.5	0.0	0.0
HYD.RAD.		0.0	0.5	0.6	2.7	1.7	1.8	1.9	1.8	1.7	1.0	0.0	0.0
Q		0	0	99	56	0	0	0	0	0	285	0	0
STAGE:	39.7												
WET PER.		0.0	62.2	66.7	1.9	4.1	18.1	22.2	28.4	31.3	67.3	75.4	0.0
AREA		0.0	46.0	55.6	5.9	8.4	39.9	49.7	62.1	66.5	95.0	96.5	0.0
HYD.RAD.		0.0	0.7	0.8	3.1	2.0	2.2	2.2	2.2	2.1	1.4	1.3	0.0
Q		0	0	201	71	0	0	0	0	0	0	465	0
STAGE:	40.1												
WET PER.		2.1	80.2	84.8	1.9	4.1	18.1	22.2	28.4	31.3	67.3	84.0	0.0
AREA		0.0	74.2	85.5	6.6	9.9	46.9	58.3	73.1	78.7	121.5	128.0	0.0
HYD.RAD.		0.0	0.9	1.0	3.5	2.4	2.6	2.6	2.6	2.5	1.8	1.5	0.0
Q		0	0	351	87	0	0	0	0	0	0	692	0
STAGE:	40.5												
WET PER.		44.4	122.6	127.1	1.9	4.1	18.1	22.2	28.4	31.3	67.3	92.5	0.0
AREA		9.3	114.8	127.8	7.4	11.4	53.9	66.9	84.1	90.8	148.0	162.9	0.0
HYD.RAD.		0.2	0.9	1.0	3.9	2.8	3.0	3.0	3.0	2.9	2.2	1.8	0.0
Q		0	0	524	104	0	0	0	0	0	0	970	0

W.S. Elev.	36.5	36.9	37.3	37.7	38.1	38.5	38.9	39.3	39.7	40.1	40.5
Q	0	3	15	41	88	164	262	440	736	1130	1597
A	0.0	1.6	5.8	12.6	24.1	39.8	66.0	105.9	157.9	220.1	298.1
V	0.1	1.7	2.6	3.3	3.6	4.1	4.0	4.2	4.7	5.1	5.4

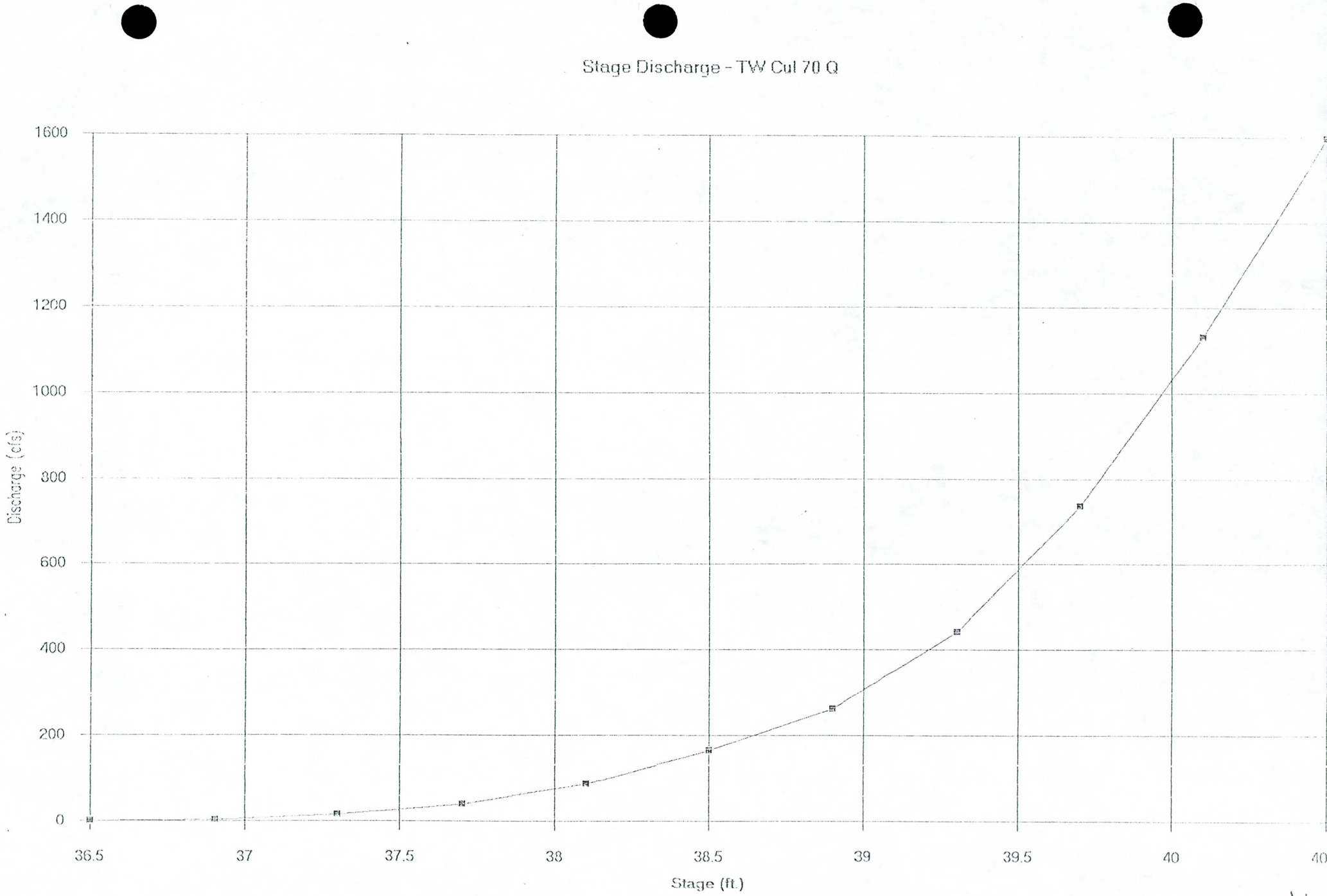
$40.1 + (40.5 - 40.1)\left(\frac{1284 - 1130}{1597 - 1130}\right) = 40.23$

$40.23' - 36.5' = 3.73'$ (depth of flow @ Q_{100})

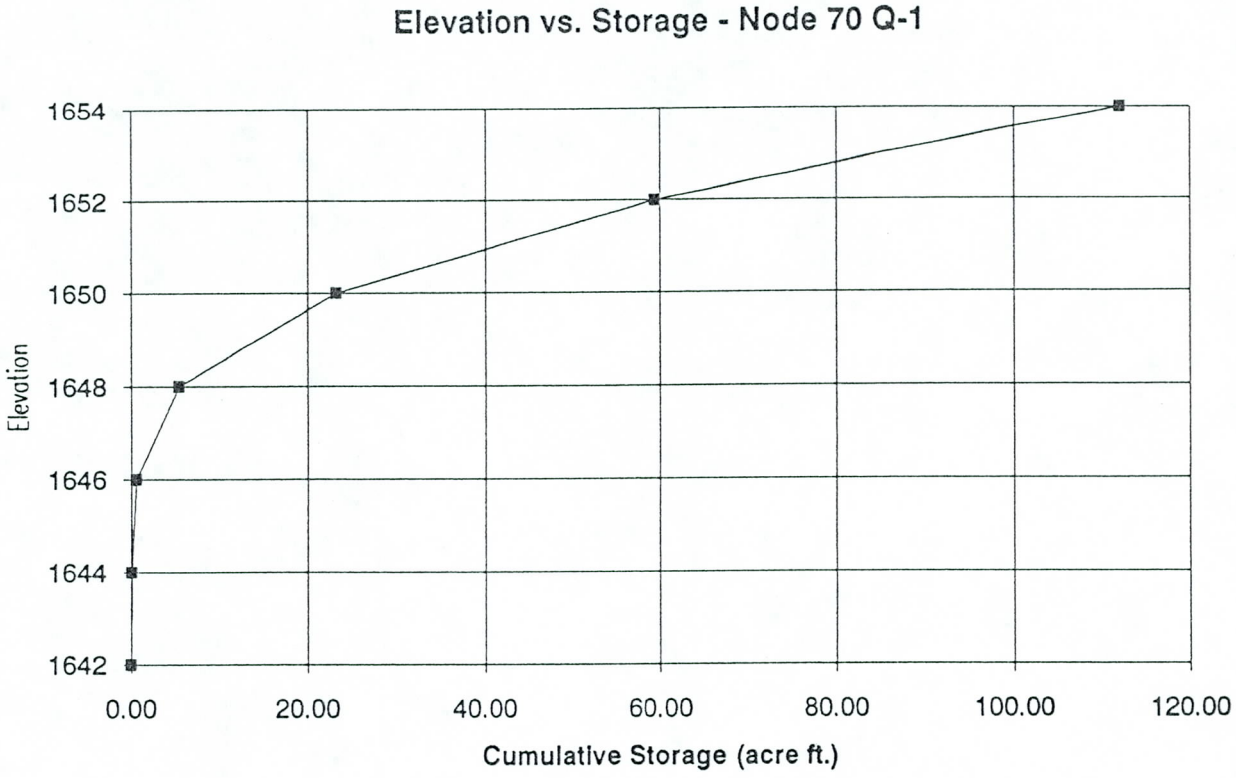
20122


Cross Section - TW Cul 70 Q
Elevation
42
41
40
39
38
37
36
-200
-150
-100
-50
0
50
100
150
200
Offset (ft.)

22/12


Stage Discharge - TW Cul 70 Q
1600
1400
1200
1000
800
600
400
200
0
Discharge (cfs)
36.5
37
37.5
38
38.5
39
39.5
40
40
Stage (ft.)

22/22


Elevation vs. Storage - Node 70 Q-1
1654
1652
1650
1648
1646
1644
1642
Elevation
0.00
20.00
40.00
60.00
80.00
100.00
120.00
Cumulative Storage (acre ft.)

SVERDF

JOB 40477 Toyota

SHEET NO. ____ OF ____

DATE 7-10-91

COMPUTATIONS FOR Proposed Culvert 70P-1 29

BY DFP CHKD RJT

CULVERT COMPUTATION SHEET

PROJECT: ____

STATION: 2+85 Loop Rd 'A'

DESIGNER: DFP

DATE: 7-3-91

HYDROLOGIC AND CHANNEL INFORMATION

DRAINAGE AREA ____

Q_1 = 2228 cfs

Q_2 = ____

TW_1 = 3.45'*

TW_2 = ____

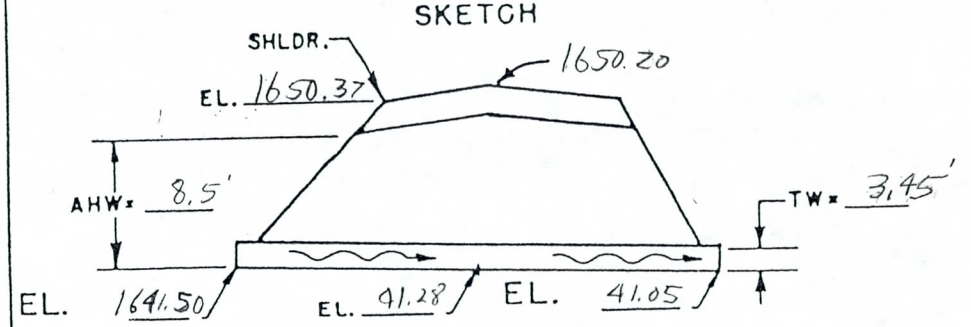
*TW derived from DHWE of 1644.50 from Culvert 70 P-2

Peak Outlet Discharge Q_{100}

(Q_1 = DESIGN DISCHARGE, SAY Q_{25})

(Q_2 = CHECK DISCHARGE, SAY Q_{50})

SKETCH



S_o = .005'/' L = 91' L/100 S_o = ____

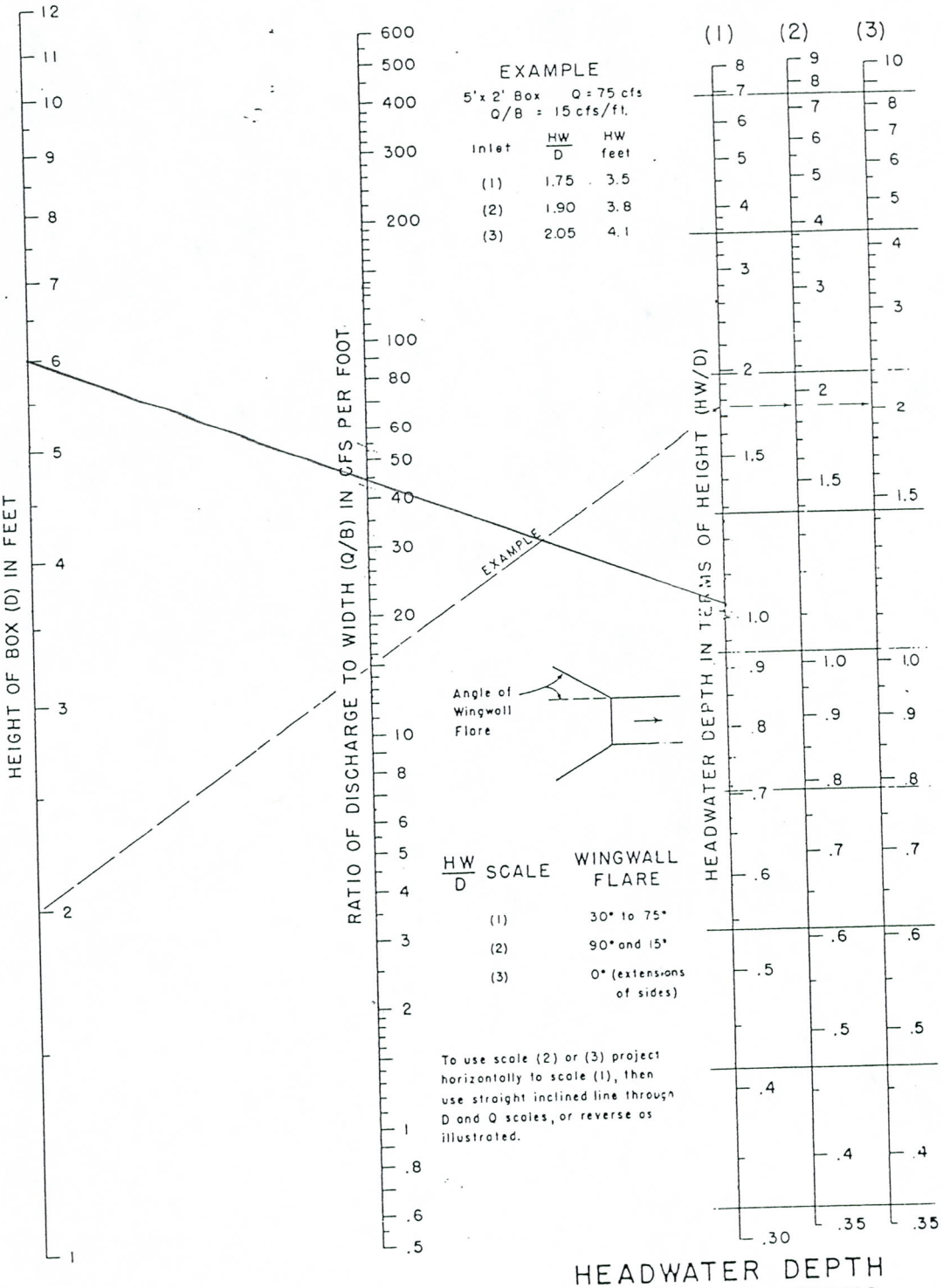
MEAN STREAM VELOCITY = 4.26 f/s

CULVERT DESCRIPTION		Q	CAP. CHART HW	HEADWATER COMPUTATION										CONTROL HW	OUTLET VELOCITY	COST	DHW ELEV.	COMMENTS
				INLET CONT.		OUTLET CONTROL $HW = H + h_o - LS_o$												
SIZE	ENTR. TYPE			$\frac{HW}{D}$	HW	K_e	H	d_c	$\frac{d_c + D}{2}$	TW	h_o	LS_o	HW					
5 Barrel 10'x6'	Drop Inlet	445.6		1.04	6.24	.2	1.14	3.96	4.98	3.45	4.98	.45	5.67	6.24	13.75		1647.74	Inlet Control

SUMMARY & RECOMMENDATIONS

1/21

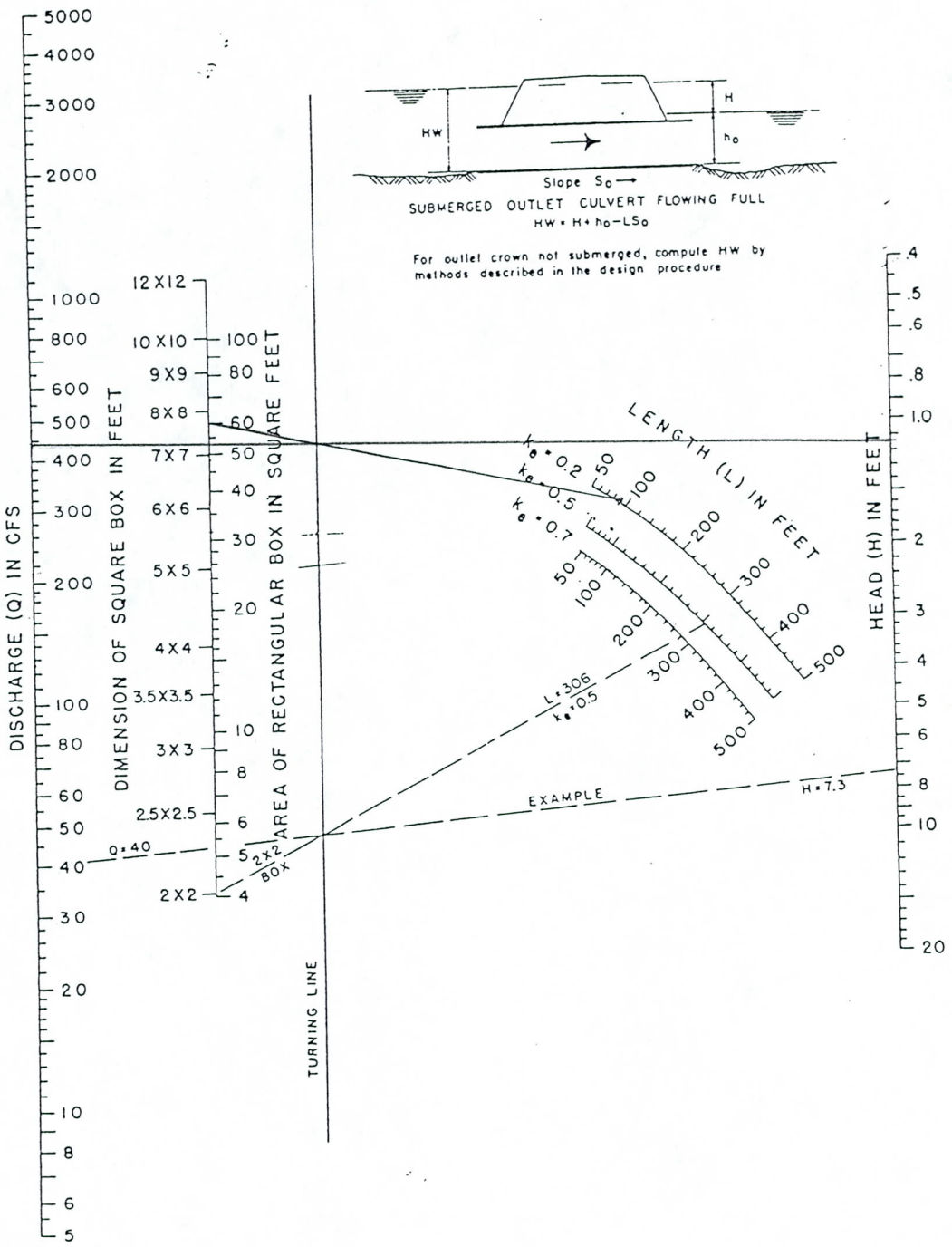
CHART I



HEADWATER DEPTH FOR BOX CULVERTS WITH INLET CONTROL

BUREAU OF PUBLIC ROADS JAN. 1963

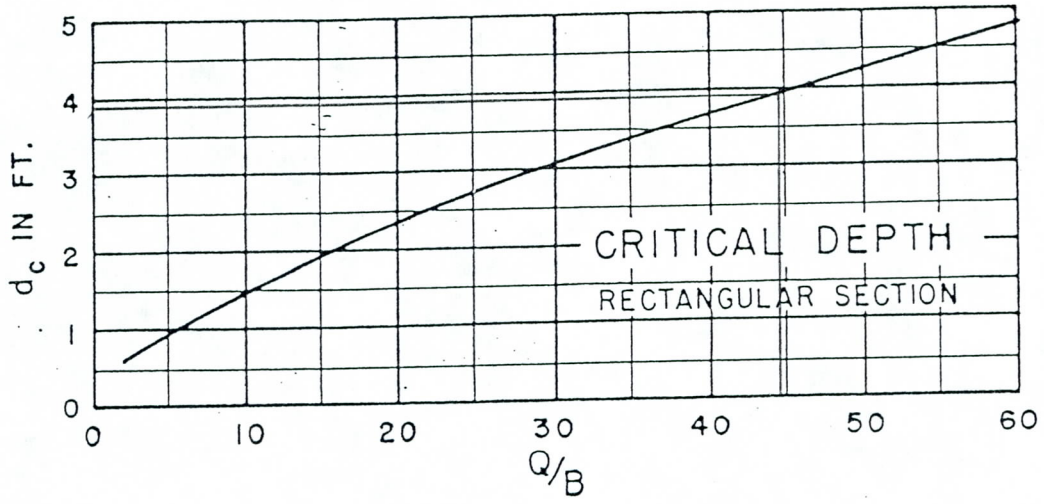
CHART 8

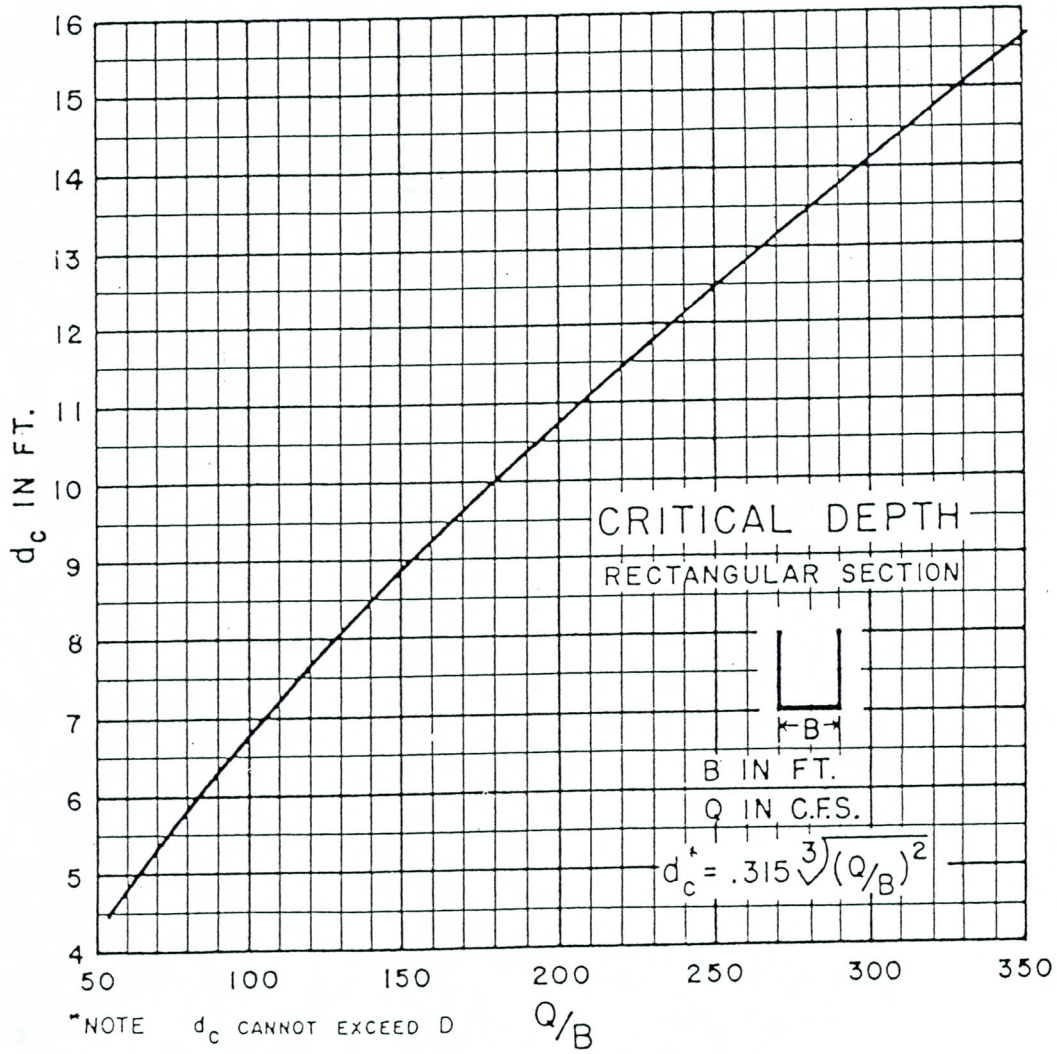


HEAD FOR
CONCRETE BOX CULVERTS
FLOWING FULL
n = 0.012

BUREAU OF PUBLIC ROADS JAN. 1963

CHART 15





BUREAU OF PUBLIC ROADS JAN 1963

SVERDRUP

JOB 40477 Toyota

SHEET NO. ____ OF ____

DATE 7-3-91

COMPUTATIONS FOR Proposed Culvert 70P-2 30

BY DFP CHKD RJT

CULVERT COMPUTATION SHEET

PROJECT: ____

STATION: 3+20 Dual Track

DESIGNER: DFP

DATE: 7-3-91

HYDROLOGIC AND CHANNEL INFORMATION

DRAINAGE AREA ____

Q_1 = 2228 cfs

Q_2 = ____

TW_1 = 4.25'*

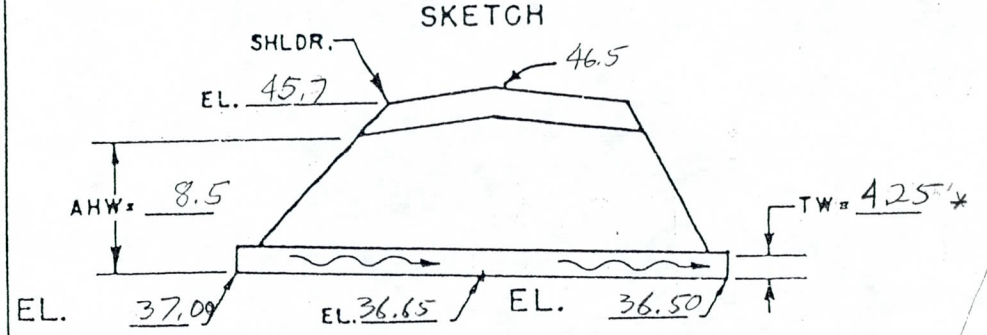
TW_2 = ____

Peak Outlet Discharge Q_{100}

(Q_1 = DESIGN DISCHARGE, SAY Q_{25})

(Q_2 = CHECK DISCHARGE, SAY Q_{50})

SKETCH



S_o = .005 L = 100' L/100 S_o = ____

MEAN STREAM VELOCITY = 4.26 f/s

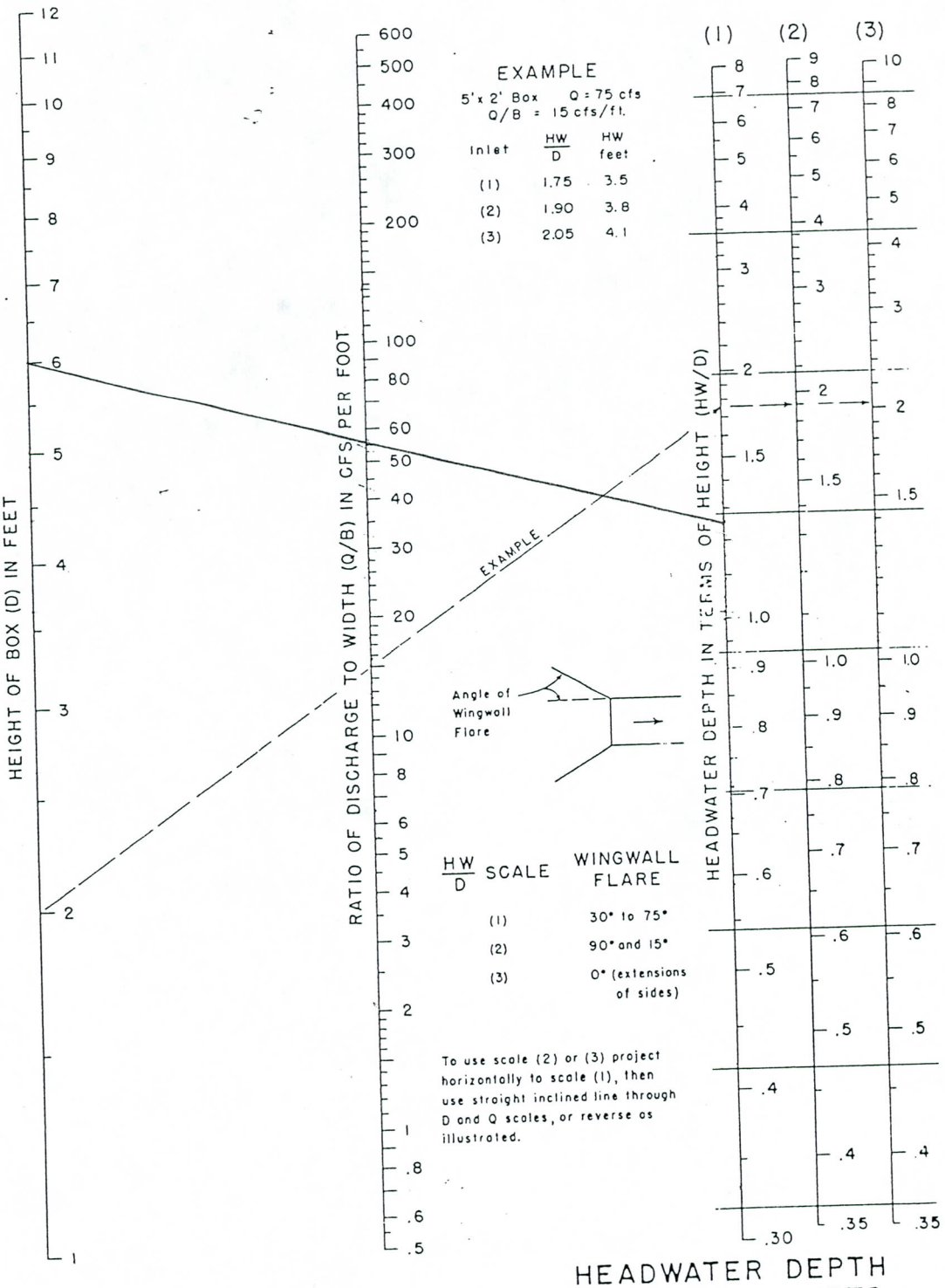
CULVERT DESCRIPTION		Q	CAP. CHART HW	HEADWATER COMPUTATION										CONTROL HW	OUTLET VELOCITY	COST	DHW ELEV.	COMMENTS
				INLET CONT.		OUTLET CONTROL $HW = H + h_o - LS_o$												
SIZE	ENTR. TYPE			$\frac{HW}{D}$	HW	K_e	H	d_c	$\frac{d_c + D}{2}$	TW	h_o	LS_o	HW					
4 Barrel 10x6	Wing wall	557		1.25	7.50	.2	1.88	4.60	5.30	4.25	5.30	.50	6.68	7.50	14.65		1644.50	Inlet Control

SUMMARY & RECOMMENDATIONS * TW derived from depth of flow at existing downstream cross section

5/21

B-1

CHART I

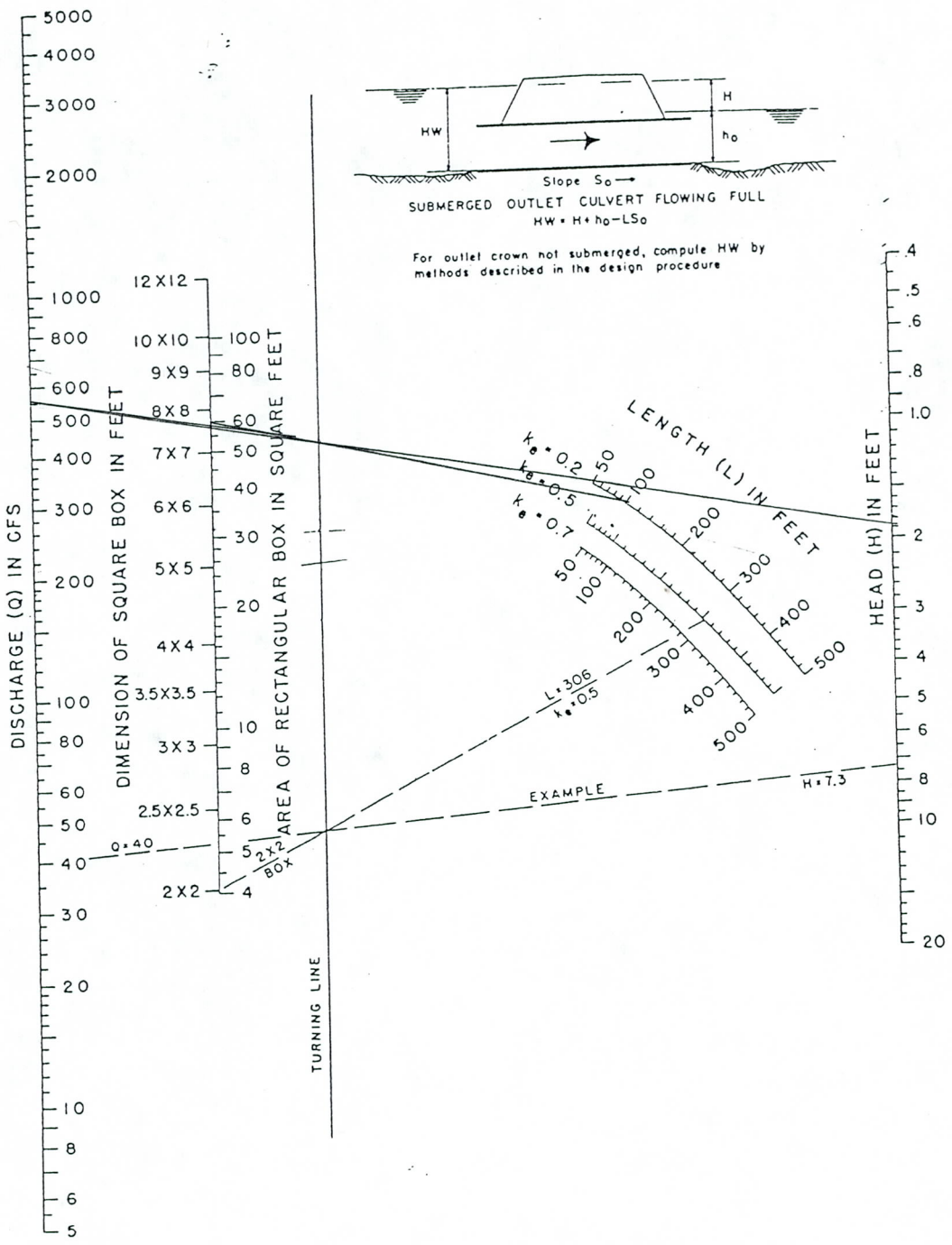


HEADWATER DEPTH FOR BOX CULVERTS WITH INLET CONTROL

BUREAU OF PUBLIC ROADS JAN. 1963

7/21

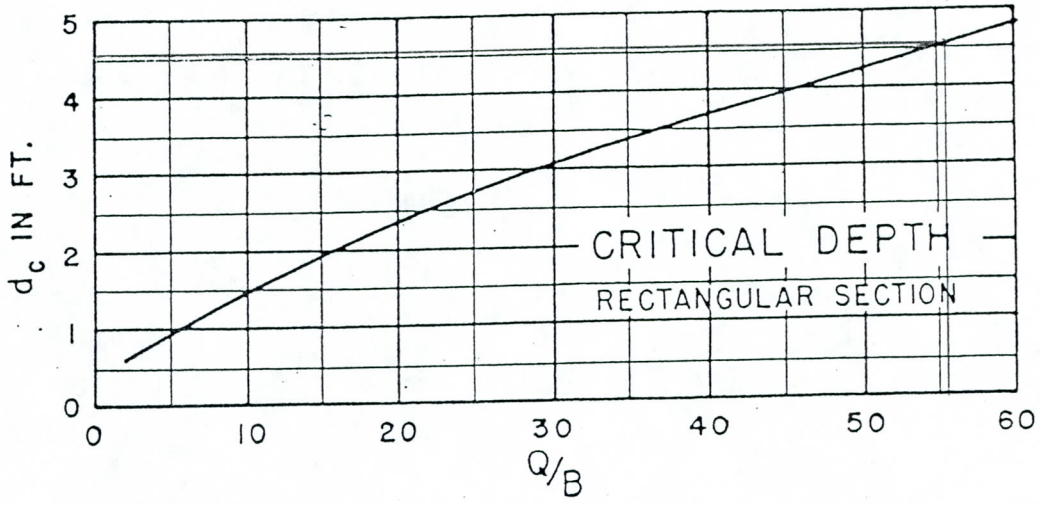
CHART 8

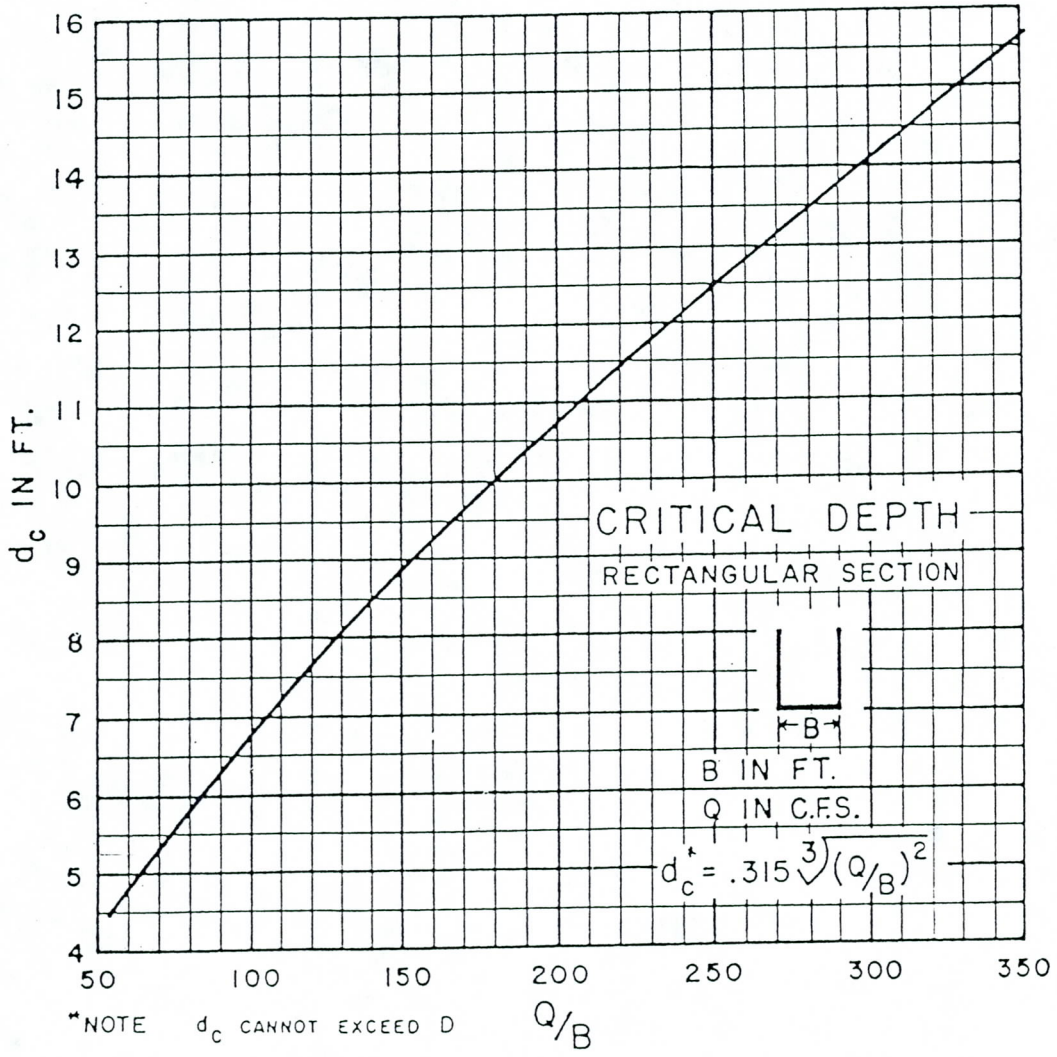


HEAD FOR CONCRETE BOX CULVERTS FLOWING FULL n = 0.012

BUREAU OF PUBLIC ROADS JAN. 1963

CHART 15





*NOTE d_c CANNOT EXCEED D

BUREAU OF PUBLIC ROADS JAN 1963

SVERDRUP

JOB 40477 Toyota

SHEET NO. 9 OF 21

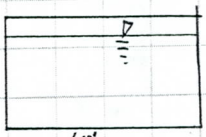
DATE 7-2-91

COMPUTATIONS FOR Culverts 70 P-1 and 70 P-2 BY DFP CHKD RJT

Check Depth of Flow using Mannings's Equation

Q_{100} = 2228 cfs for culvert 70 P-1
= 2228 cfs for culvert 70 P-2

n = .012
S_o = .005



$$N_F = \frac{V}{\sqrt{g y_n}}$$

For 70 P-1:

Q_{100} = 445.6 cfs/barrel
y_n = 3.24'

A = 32.40 ft²

V = 13.75 ft/s

$$N_F = \frac{13.75}{\sqrt{32.2\,(3.24)}}$$

= 1.35 supercritical

For 70 P-2:

Q = 557 cfs/barrel
y_n 3.80 ft/s

A = 38.03 ft²

V = 14.65 ft/s

$$N_F = \frac{14.65}{\sqrt{32.2\,(3.80)}}$$

= 1.32 supercritical

SVERDRUP

JOB 40477 Toyota SHEET NO. 10 OF 21

DATE 7-2-91

COMPUTATIONS FOR Culverts 70 P-1 and 70 P-2 BY DFP CHKD RJT

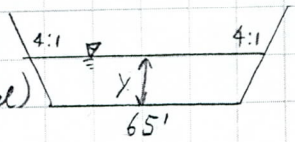
Determine Average slope between 70P-1 & 70P-2:

$$\frac{41.05 - 14.5(.005) - [37.0 + .005(9)]}{402.5 - 70 - 46 - 14.5 - 9} = \frac{3.9325}{263'} = .0150'/ft$$

Running apron-apron @ S=.0150, Mannings equation yields the following:

$Q_{100} = 2228$ cfs

$n = .02$ (soil cement channel)



$Y = 2.15'$ $V = 14.05 ft/s$ $\frac{A}{T} = \frac{158.66\ ft^2}{82.24'} = 1.93$

$$N_F = \frac{14.05}{\sqrt{32.2(1.93)}} = 1.78$$ Supercritical Flow

Recommend a 65' wide soil cement channel between culverts 70 P-1 and 70 P-2, running apron-apron, with 4:1 side slopes. Height of channel walls is determined as follows:

Since flow is supercritical and under 3' deep, minimum freeboard = $\frac{1}{6}\left(y + \frac{v^2}{2g}\right) = \frac{1}{6}\left(2.15' + \frac{14.05^2}{2(32.2)}\right) = 0.87'$

Minimum channel wall height = 2.15' + .87 = 3.02' ⇒ Use 3.0'

SVERDRUP

JOB 40477 Toyota SHEET NO. 11 OF 21

COMPUTATIONS FOR Culverts 70P-1 and 70P-2 DATE 7-3-91 BY DFA CHKD RJT

Evaluate Flow of 70P-2 Discharge:

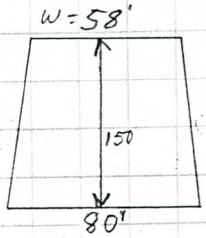
$Q_{100} = 222.8$ cfs $n = .02$, $S = .002$

For 58' Wide channel, w/ 4:1 side slopes:

$y = 4.07'$ $V = 7.37$ ft/s for Q_{100} $\frac{A}{T} = \frac{302.22}{90.56} = 3.34$

$N_F = \frac{7.37}{\sqrt{32.2\,(3.34)}} = .71$ Subcritical

Increase width of channel:



at 150', width increase to 80'

$y = 3.45'$ $V = 6.89$ ft/s

$N_F = \frac{6.89}{\sqrt{32.2\,(3.01)}} = .70$ sub-critical

where $\frac{A}{T} = \frac{323.40}{107.60} = 3.01$

Cutoff Wall:

Per HEC No. 14, Hydraulic Design of Energy Dissipators for Culverts and Channels by FHWA; and Drainage and Design Standards for Floodplain Management within Pima Co. Ariz, by Pima Co. D.O.T. and F.C.D.:

The downstream depth of Scour is:

$h_s = \alpha\, y_c^{\gamma} \left(Q/y_c^{2.5}\right)^{\beta} t^{\theta}$

For TW 7.50 (From Table V-1, HEC No. 14)

$\alpha = .76$ $\beta = .375$ $\theta = 0.10$ and $\gamma = 1.0$

$\therefore h_s = .76\, y_c \left(Q/y_c^{2.5}\right)^{.375} t^{0.1}$

$Q = VA$ and $A = 2y_c^2$ $\therefore h_s = .76\, y_c \left(\frac{V 2y_c^2}{y_c^{2.5}}\right)^{.375} t^{0.1}$

where V = average velocity, ft/s y_c = max depth

t = time duration, minutes

SVERDRUP

JOB 40477 Toyota SHEET NO. 12 OF 21

COMPUTATIONS FOR Culverts 70P-1 and 70P-2 DATE 8-12-9

BY DFP CHKD RVT

For the 80' channel, $V = 6.89$ ft/s $y_c = 3.45$

$S = .002$ $t = 35$ min

$$\Rightarrow h_s = .76(3.45)\left(\frac{6.89(2)(3.45)^2}{3.45^{2.5}}\right)^{.375} 35^{.1} = 7.93'$$

Use $h_s = 8'$

Determine Height of channel walls:

Since $N_F < 0.86$ and $y_n < 3'$ deep, minimum freeboard $= \frac{1}{6}\left(y_n + \frac{V^2}{2g}\right) = \frac{1}{6}\left(3.45 + \frac{6.89^2}{2g}\right)$

$= .70'$

Minimum depth of channel = $3.45 + .70 = 4.15$

Use 4.5'

Evaluate 70 P-2 discharge along Rock channel:

$W = 80'$ $S = .002$ $Q_{100} = 2228$ cfs

$n = .032$ 4:1 side slopes

Initial Velocity hitting cobbles = 6.89 ft/s

Velocity in Rock area (from Mannings) = 5.04 ft/s, $y = 4.51'$

This approaches velocity of existing wash 4.26 ft/s.

⇒ Install 50' section of 6" cobbles (riprap). Match existing channels at downstream end by grading earthen channel at $S = 0.004$'/ft to daylight at 500'±.

78 P-2

13/21

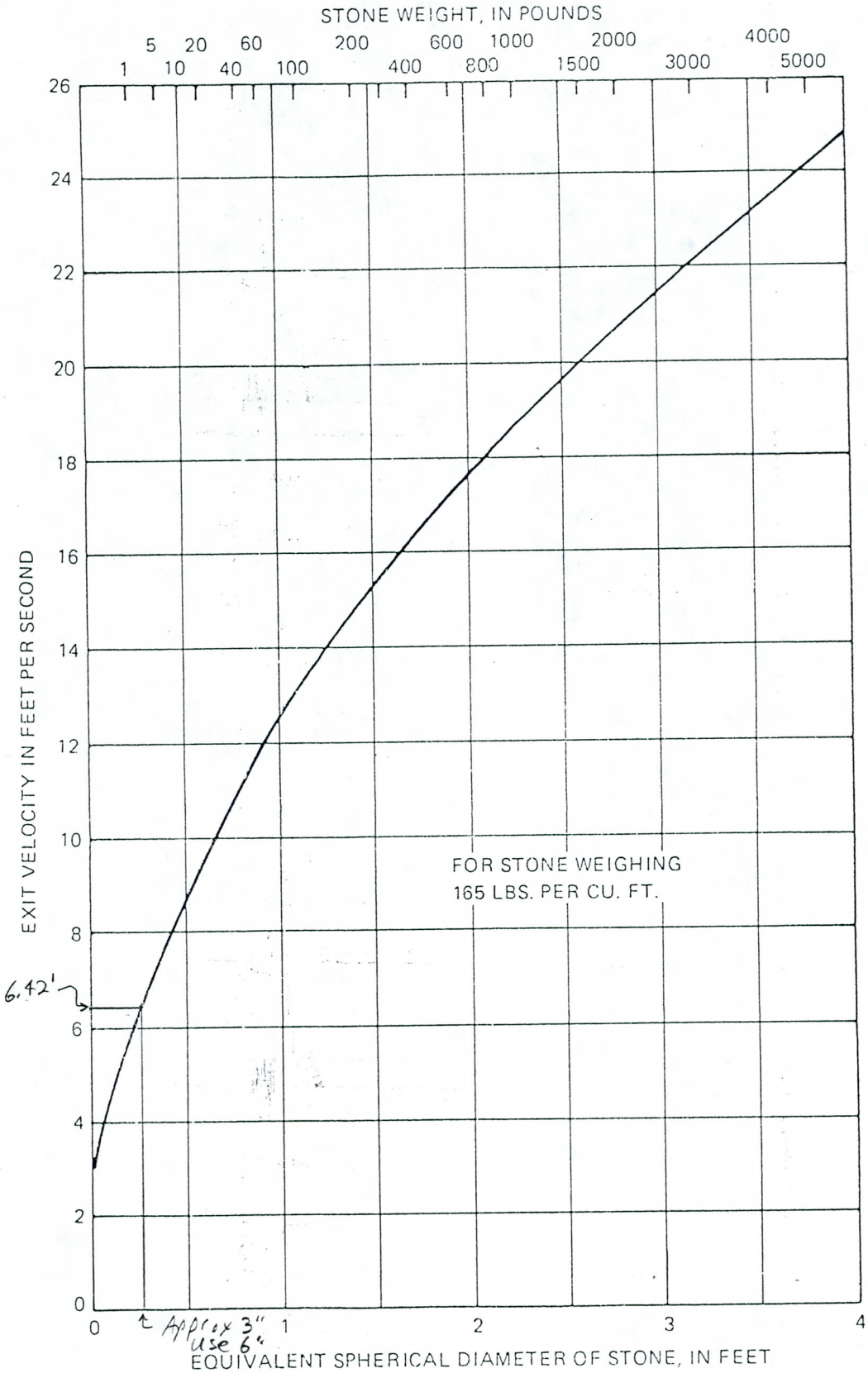


FIGURE II-C-1. RIPRAP SIZE FOR USE DOWNSTREAM OF ENERGY DISSIPATORS FROM REFERENCE II-C-1.

SVERDRUP

JOB 40477 Toyota

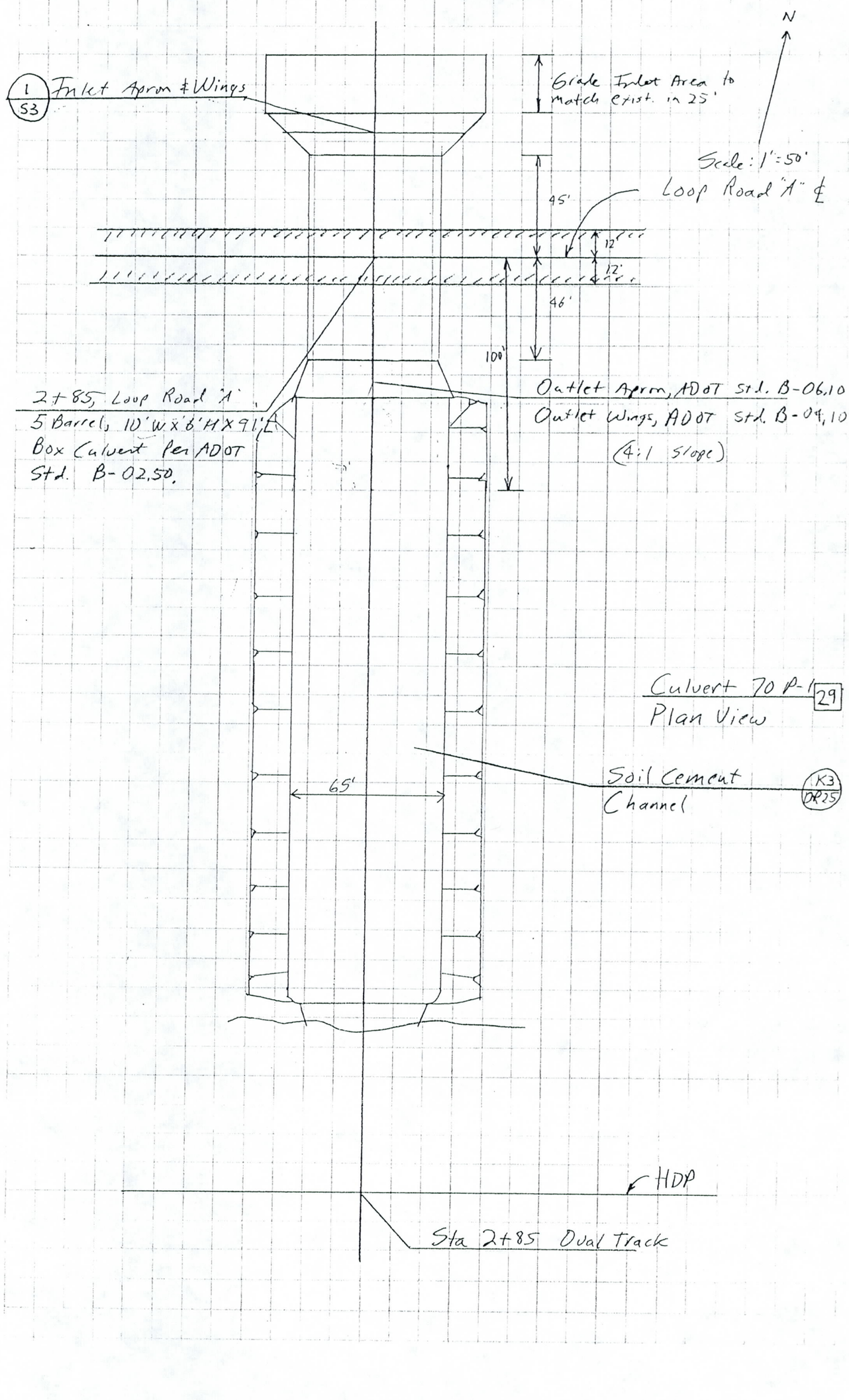
SHEET NO. 14 OF 21

DATE 8-21-91

COMPUTATIONS FOR Culvert 70 P-1 [29]

BY DFP CHKD RJT

Plan View, Sta 2+85 Loop Road "A"



SVERDRUP

JOB 40477 Toyota

COMPUTATIONS FOR Culvert Profile Loop Rd "A", Sta 2+85

DATE 7-3-91

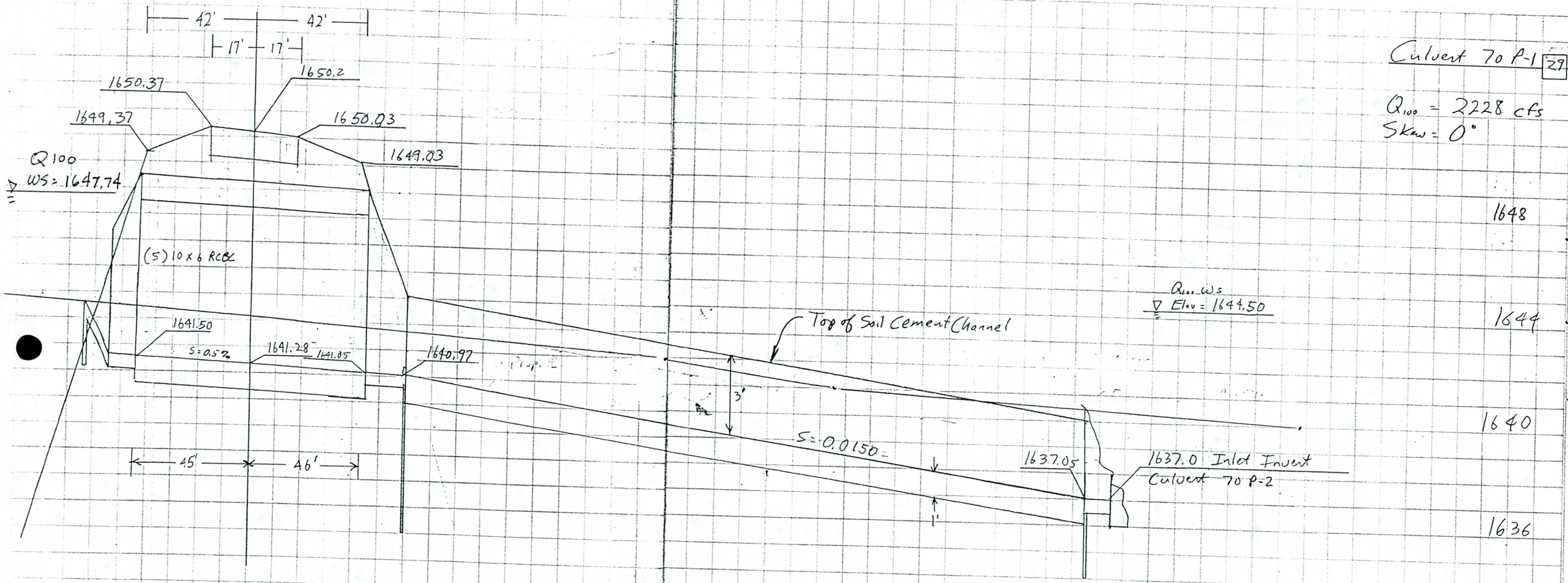
BY DFP CHKD RVT

SHEET NO. 15 OF 21

Culvert 70 P-1 29

Q_{100} = 2228 cfs

Skew = 0°



Loop Road "A"
Sta 2+85
Looking Downstation

Scale:
Horiz: 1" = 40'
Vert: 1" = 4'

SVERDRUP

JOB 10477 Toyota

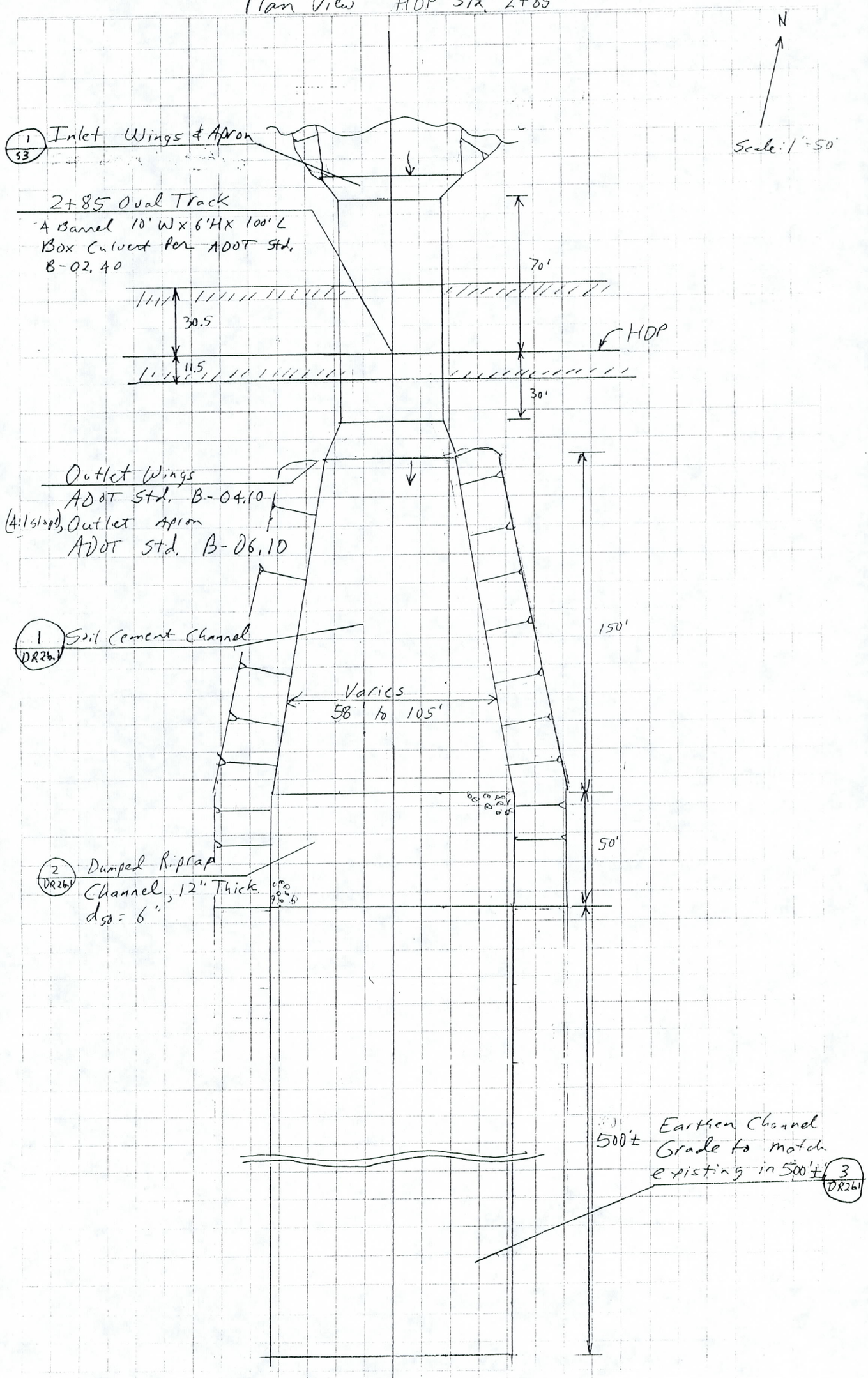
SHEET NO. 16 OF 21

DATE 7-2-91

COMPUTATIONS FOR Culvert 70 P-2 [30]

BY DFP CHKD RJT

Plan View HDP Sta. 2+85



SVERDRUP

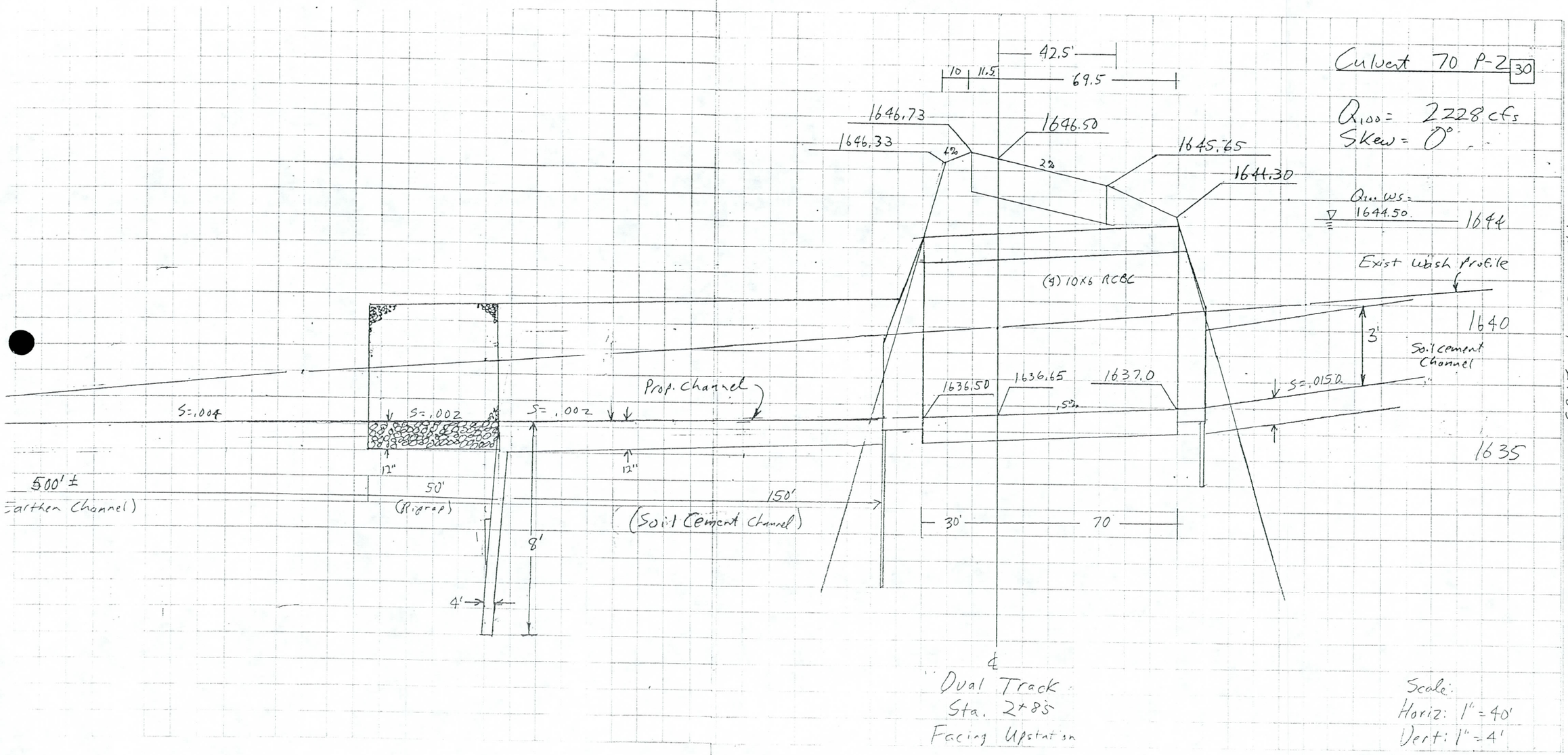
JOB 40477 Toyota

COMPUTATIONS FOR Culvert Profile HDP Sta. 2+85

Culvert 70 P-2 30

Q_{100} = 2228 cfs

Skew = 0°



Scale:
Horiz: 1" = 40'
Vert: 1" = 4'

SHEET NO. 17 OF 21

DATE 6-18-91

BY DFP CHKD RVT

SECTION NUMBER TW70P-2 6/12/91

Channel Slope: 0.0079 ft./ft.

CROSS SECTION DATA:

OFFSET	-200	1.1	75.2	76.7	79.3	82	96.2	99.8	102	107.6	194.2	400
ELEV.	39.5	37.3	36.39	34.63	34.5	36.01	36.79	35.99	35.85	37.12	37.56	39.5
N	N/A	0.035	0.035	0.035	0.025	0.035	0.035	0.035	0.035	0.035	0.035	0.035

STAGE-DISCHARGE DATA:

STAGE:	34.7												
WET PER.		0.0	0.0	0.1	2.6	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
AREA		0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYD.RAD.		0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Q		0	0	0	0	0	0	0	0	0	0	0	0
STAGE:	35.1												
WET PER.		0.0	0.0	0.6	2.6	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
AREA		0.0	0.0	0.1	1.4	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYD.RAD.		0.0	0.0	0.2	0.5	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Q		0	0	0	5	0	0	0	0	0	0	0	0
STAGE:	35.5												
WET PER.		0.0	0.0	1.1	2.6	2.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
AREA		0.0	0.0	0.3	2.4	0.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYD.RAD.		0.0	0.0	0.3	0.9	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Q		0	0	1	12	2	0	0	0	0	0	0	0
STAGE:	35.9												
WET PER.		0.0	0.0	1.7	2.6	2.9	0.0	0.0	0.8	1.0	0.0	0.0	0.0
AREA		0.0	0.0	0.7	3.5	1.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYD.RAD.		0.0	0.0	0.4	1.3	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Q		0	0	1	22	5	0	0	0	0	0	0	0
STAGE:	36.3												
WET PER.		0.0	0.0	2.2	2.6	3.1	8.4	1.4	3.6	5.7	0.0	0.0	0.0
AREA		0.0	0.0	1.2	4.5	2.8	3.6	0.2	1.1	1.5	0.0	0.0	0.0
HYD.RAD.		0.0	0.0	0.5	1.7	0.9	0.4	0.2	0.3	0.3	0.0	0.0	0.0
Q		0	0	3	34	0	8	0	0	2	0	0	0
STAGE:	36.7												
WET PER.		0.0	25.2	27.6	2.6	3.1	15.7	3.3	5.5	9.3	0.0	0.0	0.0
AREA		0.0	3.9	5.7	5.6	3.9	8.2	1.1	2.9	4.4	0.0	0.0	0.0
HYD.RAD.		0.0	0.2	0.2	2.1	1.3	0.5	0.3	0.5	0.5	0.0	0.0	0.0
Q		0	0	7	48	0	20	0	0	10	0	0	0

12/81

SECTION NUMBER TW70P-2 6/12/91

STAGE:	37.1											
WET PER.		0.0	57.8	60.1	2.6	3.1	17.3	21.0	23.2	28.9	0.0	0.0	0.0
AREA		0.0	20.5	22.9	6.6	5.0	14.9	17.5	20.1	23.5	0.0	0.0	0.0
HYD.RAD.		0.0	0.4	0.4	2.5	1.6	0.9	0.8	0.9	0.8	0.0	0.0	0.0
Q		0	0	45	64	0	0	0	0	77	0	0	0
STAGE:	37.5												
WET PER.		18.3	92.4	94.7	2.6	3.1	17.3	21.0	23.2	28.9	103.7	0.0	0.0
AREA		1.8	50.4	53.3	7.6	6.1	21.7	25.7	29.2	34.8	49.0	0.0	0.0
HYD.RAD.		0.1	0.5	0.6	2.9	2.0	1.3	1.2	1.3	1.2	0.5	0.0	0.0
Q		0	0	137	82	0	0	0	0	0	112	0	0
STAGE:	37.9												
WET PER.		54.9	129.0	131.3	2.6	3.1	17.3	21.0	23.2	28.9	115.6	151.6	0.0
AREA		16.5	94.6	98.2	8.7	7.1	28.4	33.9	38.2	46.2	94.7	100.8	0.0
HYD.RAD.		0.3	0.7	0.7	3.3	2.3	1.6	1.6	1.6	1.6	0.8	0.7	0.0
Q		0	0	304	102	0	0	0	0	0	0	289	0
STAGE:	38.3												
WET PER.		91.4	165.5	167.8	2.6	3.1	17.3	21.0	23.2	28.9	115.6	194.1	0.0
AREA		45.7	153.5	157.7	9.7	8.2	35.2	42.1	47.3	57.5	140.6	169.7	0.0
HYD.RAD.		0.5	0.9	0.9	3.7	2.7	2.0	2.0	2.0	2.0	1.2	0.9	0.0
Q		0	0	569	123	0	0	0	0	0	0	584	0
STAGE:	38.7												
WET PER.		128.0	202.1	204.4	2.6	3.1	17.3	21.0	23.2	28.9	115.6	236.5	0.0
AREA		89.6	227.0	231.8	10.8	9.3	42.0	50.3	56.4	68.8	186.6	255.5	0.0
HYD.RAD.		0.7	1.1	1.1	4.1	3.0	2.4	2.4	2.4	2.4	1.6	1.1	0.0
Q		0	0	948	146	0	0	0	0	0	0	1012	0

W.S. Elev.	34.7	35.1	35.5	35.9	36.3	36.7	37.1	37.5	37.9	38.3	38.7
Q	1	5	15	28	47	86	187	331	695	1276	2106
A	0.4	1.8	3.6	5.9	10.8	23.9	53.0	110.0	207.7	337.1	498.1
V	1.3	3.0	4.0	4.8	4.4	3.6	3.5	3.0	3.3	3.8	4.2

for $Q_{100} = 2228$ cfs

WS Elev $= 38.3 + \left(\frac{2228-1276}{2106-1276}\right)(38.7-38.3)$

$= 38.76'$

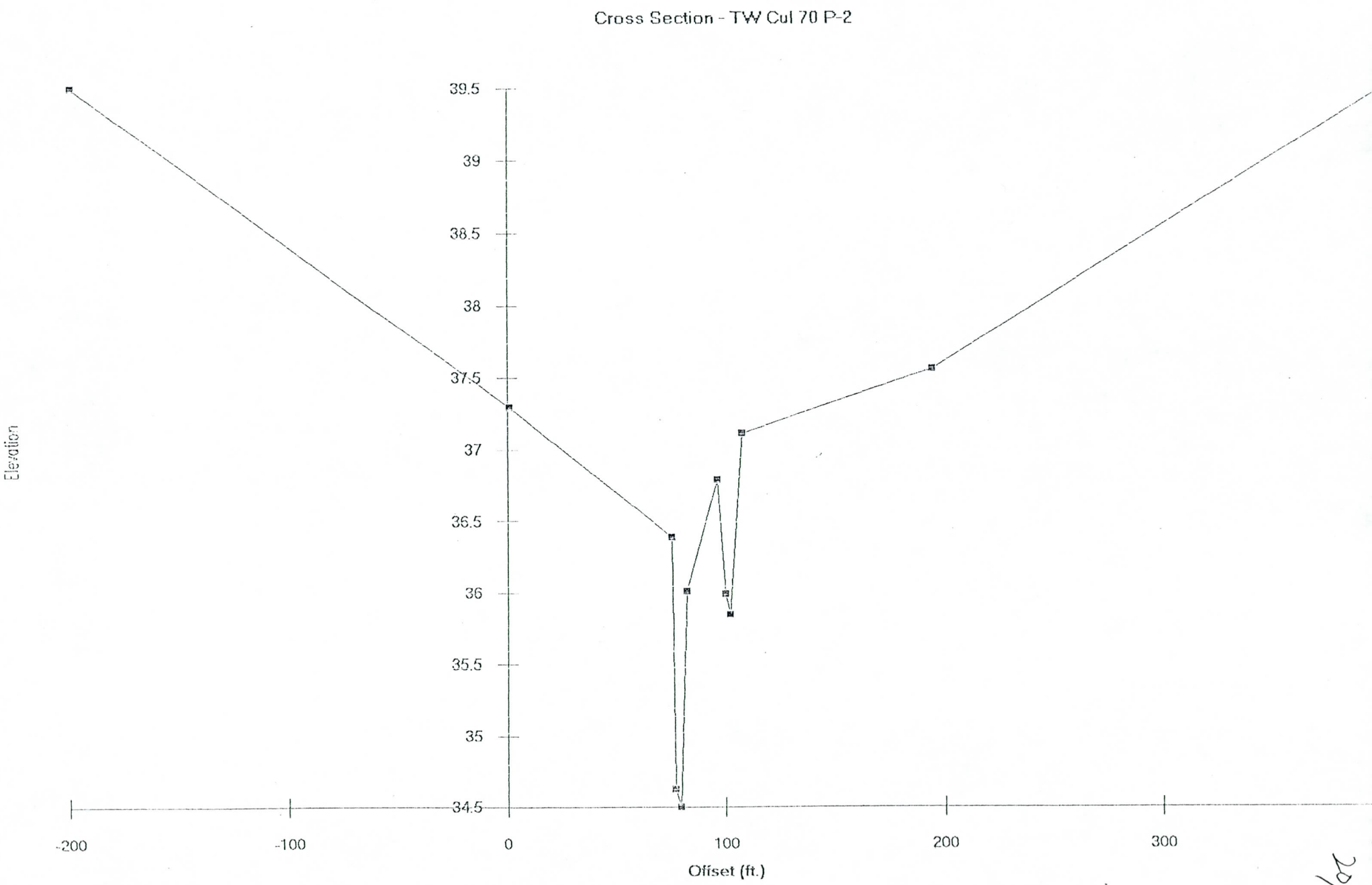
$V = 3.8 + \left(\frac{2228-1276}{2106-1276}\right)(4.2-3.8)$

$= 4.26$ ft/s

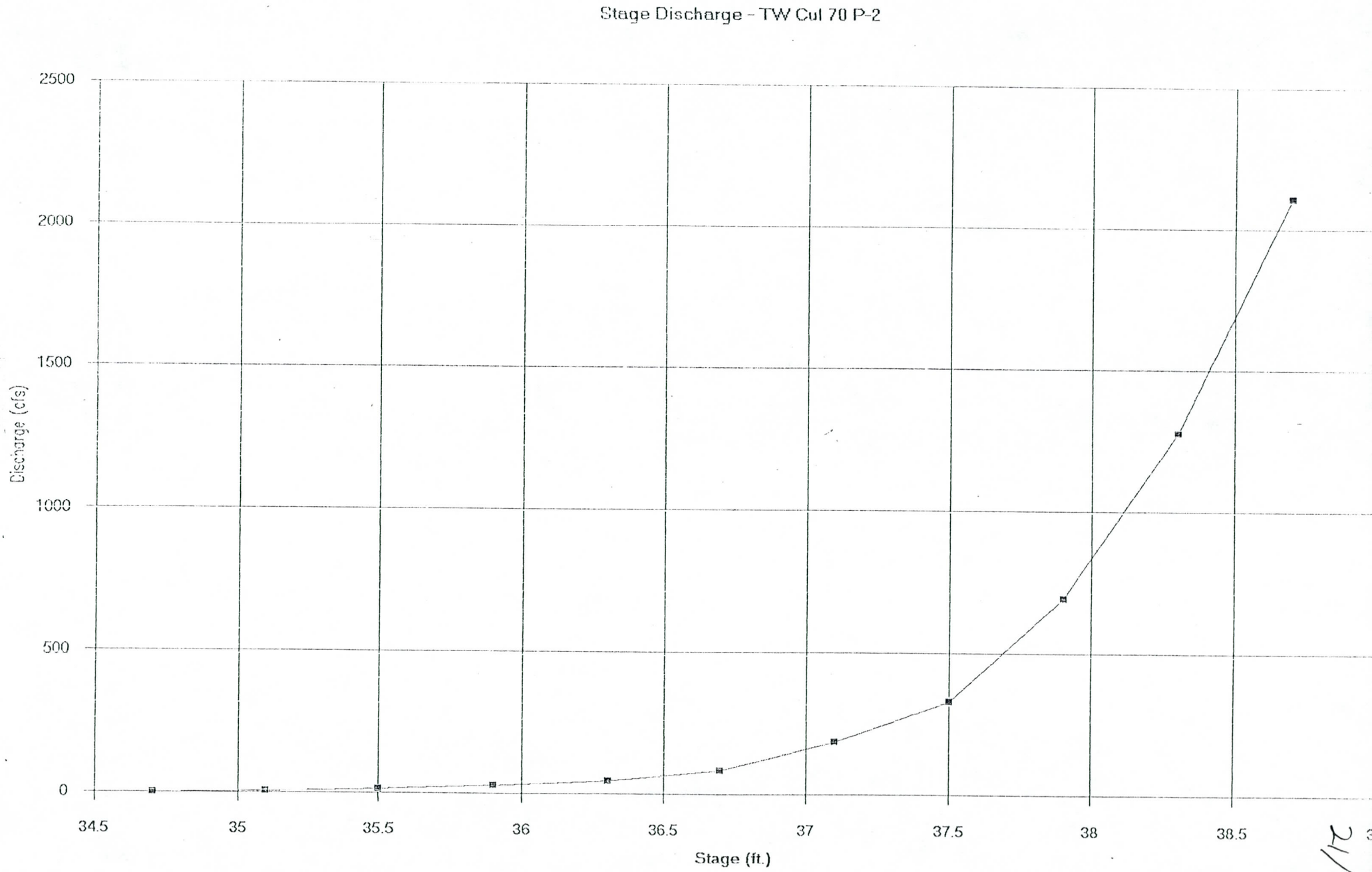
Depth $= 38.76' - 34.5 = 4.26'$

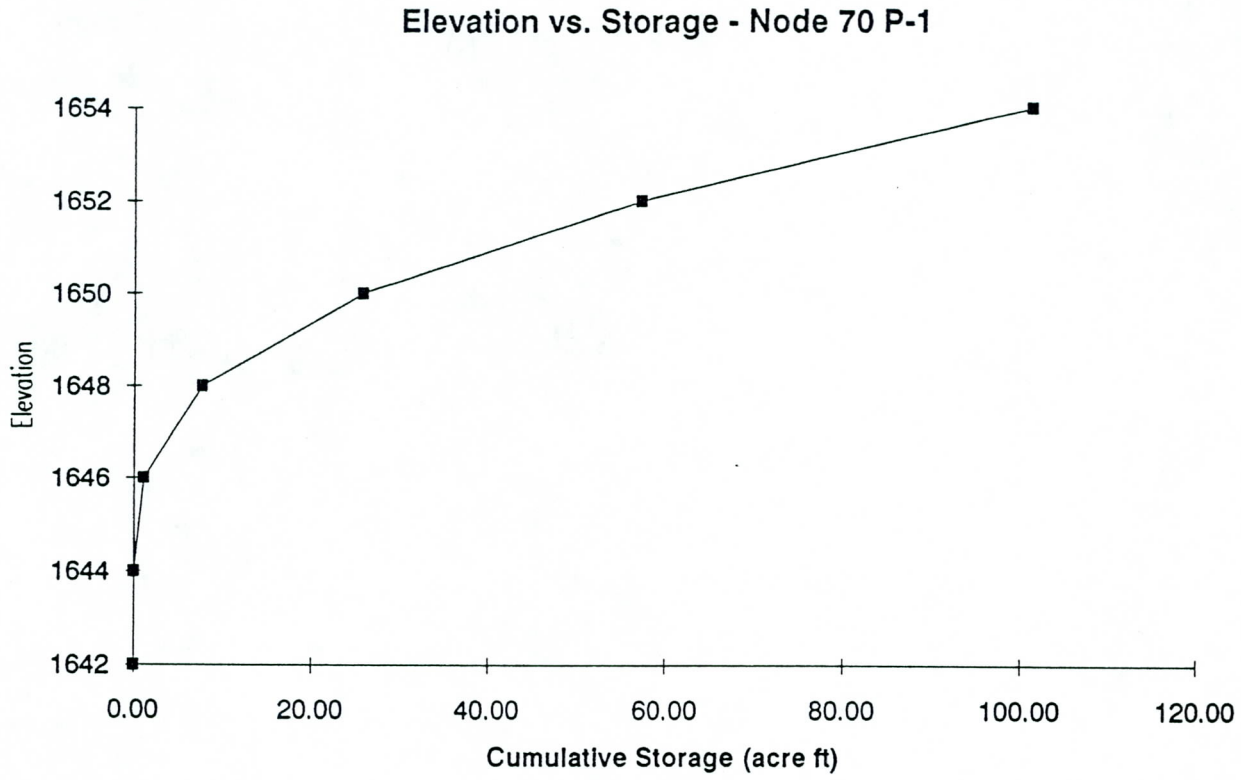
use 4.25 for TW

7/1/


Cross Section - TW Cul 70 P-2
Elevation
39.5
39
38.5
38
37.5
37
36.5
36
35.5
35
34.5
-200
-100
0
100
200
300
Offset (ft.)

2 of 2


Stage Discharge - TW Cul 70 P-2
2500
2000
1500
1000
500
0
Discharge (cfs)
34.5
35
35.5
36
36.5
37
37.5
38
38.5
Stage (ft.)


Elevation vs. Storage - Node 70 P-1
1654
1652
1650
1648
1646
1644
1642
Elevation
0.00
20.00
40.00
60.00
80.00
100.00
120.00
Cumulative Storage (acre ft)

SVERDR[illegible]

JOB 404 Toyota

COMPUTATIONS FOR Culvert 70-0 [31]

SHEET NO 1 OF

DATE 7/18/91

BY BDO CHKD KJT

CULVERT COMPUTATION SHEET

PROJECT:

STATION: 520+50, Oval Track

DESIGNER:

DATE:

HYDROLOGIC AND CHANNEL INFORMATION

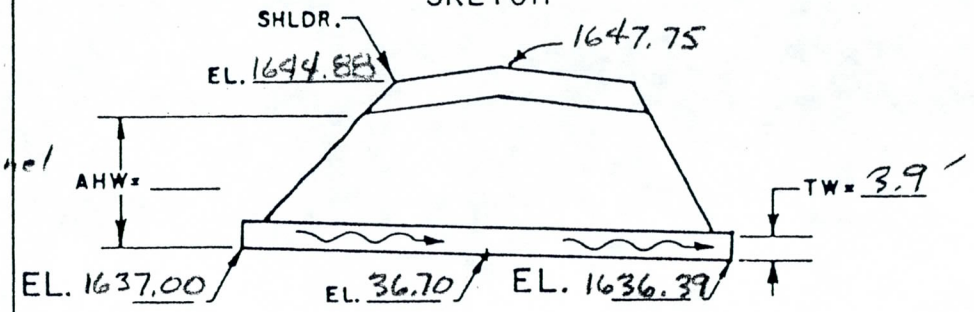
DRAINAGE AREA 1.07 Sq. Miles

Q_1 = 938 cfs
Q_2 =

TW_1 = 3.9' Exist. Channel
TW_2 =

Peak Outlet Discharge
(Q_1 = DESIGN DISCHARGE, SAY ~~Q_{25}~~ Q_{100})
(Q_2 = CHECK DISCHARGE, SAY Q_{50})

SKETCH



S_o = .0050' L = 122' L/100 S_o =

MEAN STREAM VELOCITY = 8.2 fps

CULVERT DESCRIPTION		Q	CAP. CHART HW	HEADWATER COMPUTATION										CONTROL HW	OUTLET VELOCITY	COST	DHW ELEV.	COMMENTS
				INLET CONT.		OUTLET CONTROL $HW = H + h_o - LS_o$												
SIZE	ENTR. TYPE			$\frac{HW}{D}$	HW	K_e	H	d_c	$\frac{d_c + D}{2}$	TW	h_o	LS_o	HW					
(2) Barrel 10'x4'	Drop Inlet	938/2 = 469		2.0	8.0	0.2	3.2	4.0	4.0	3.9	4.0	0.61	6.59	8.0	14.0		1645.00	Inlet Control

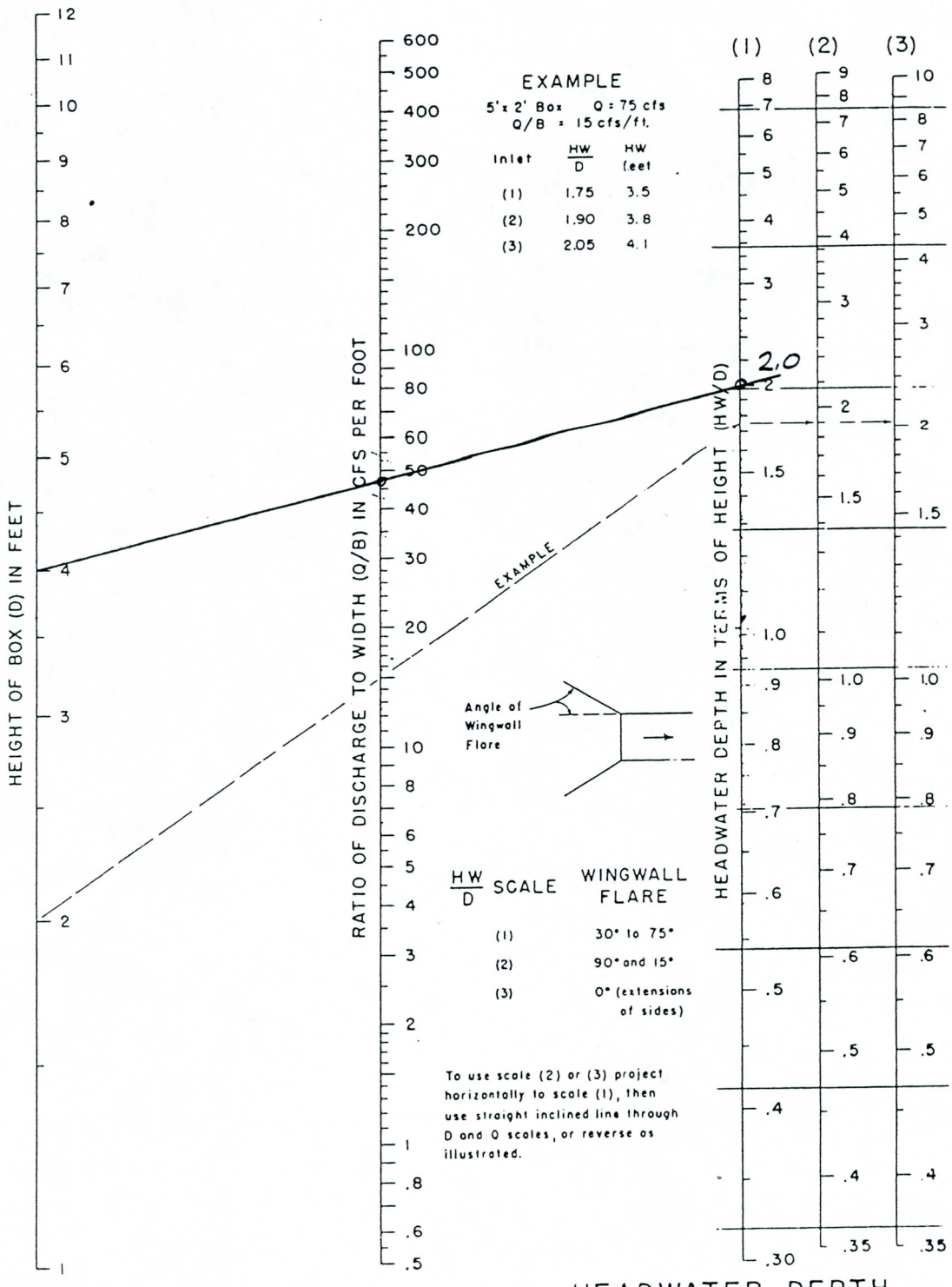
SUMMARY & RECOMMENDATIONS Use grouted riprap plunge basin to reduce downstream erosion protection.

B-1

Culvert 70 O

2

CHART I

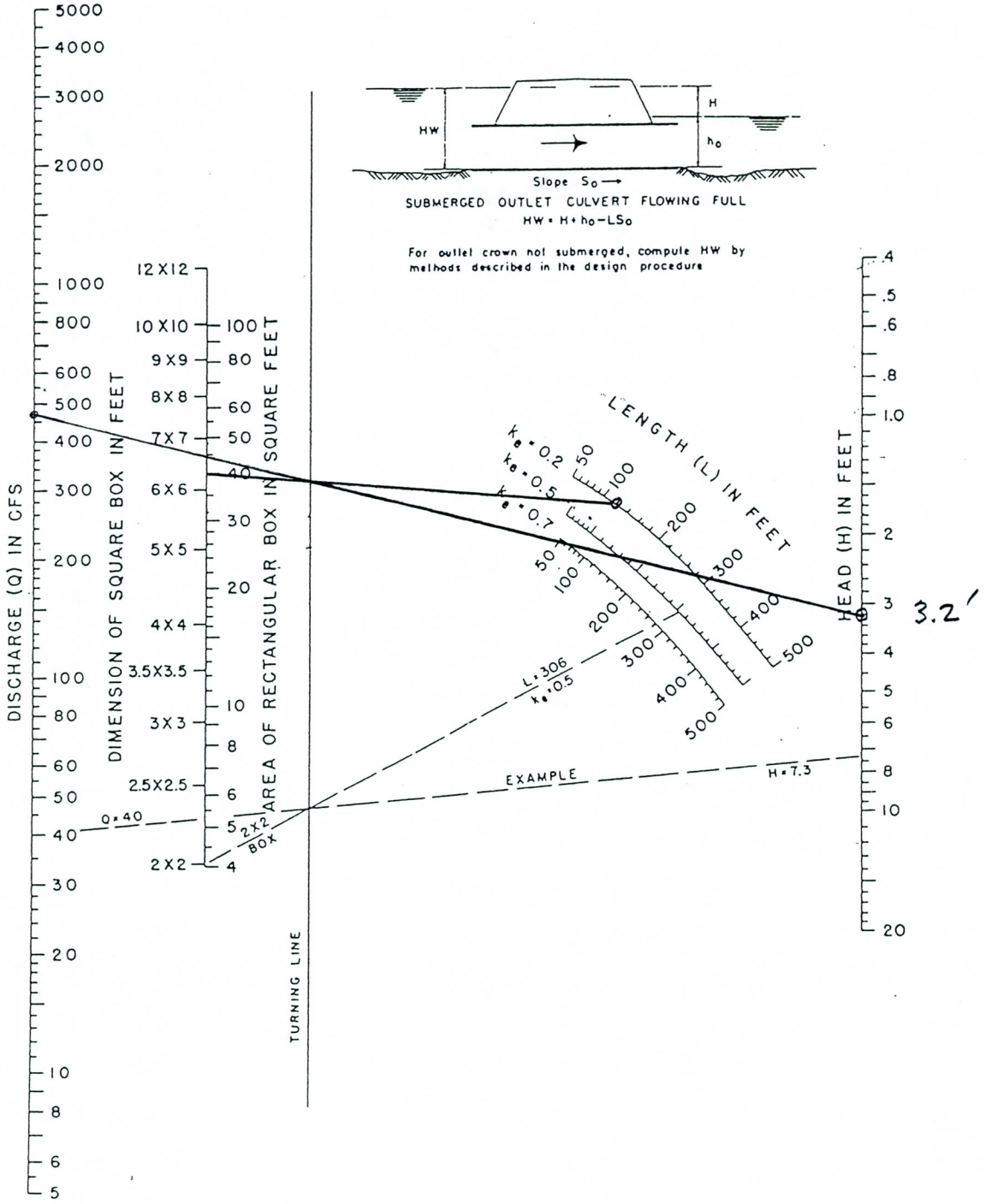


HEADWATER DEPTH FOR BOX CULVERTS WITH INLET CONTROL

BUREAU OF PUBLIC ROADS JAN. 1953

Culvert 70-0

CHART 8

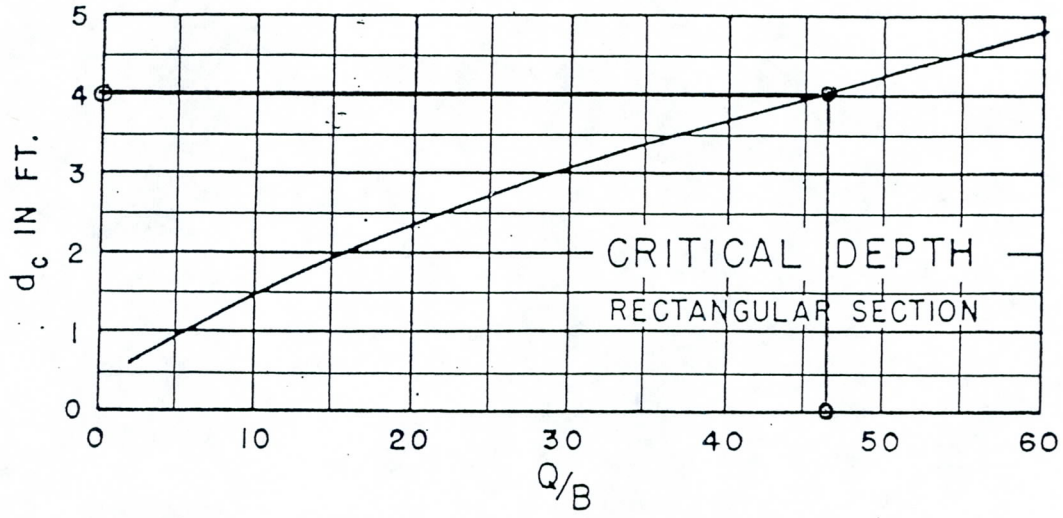


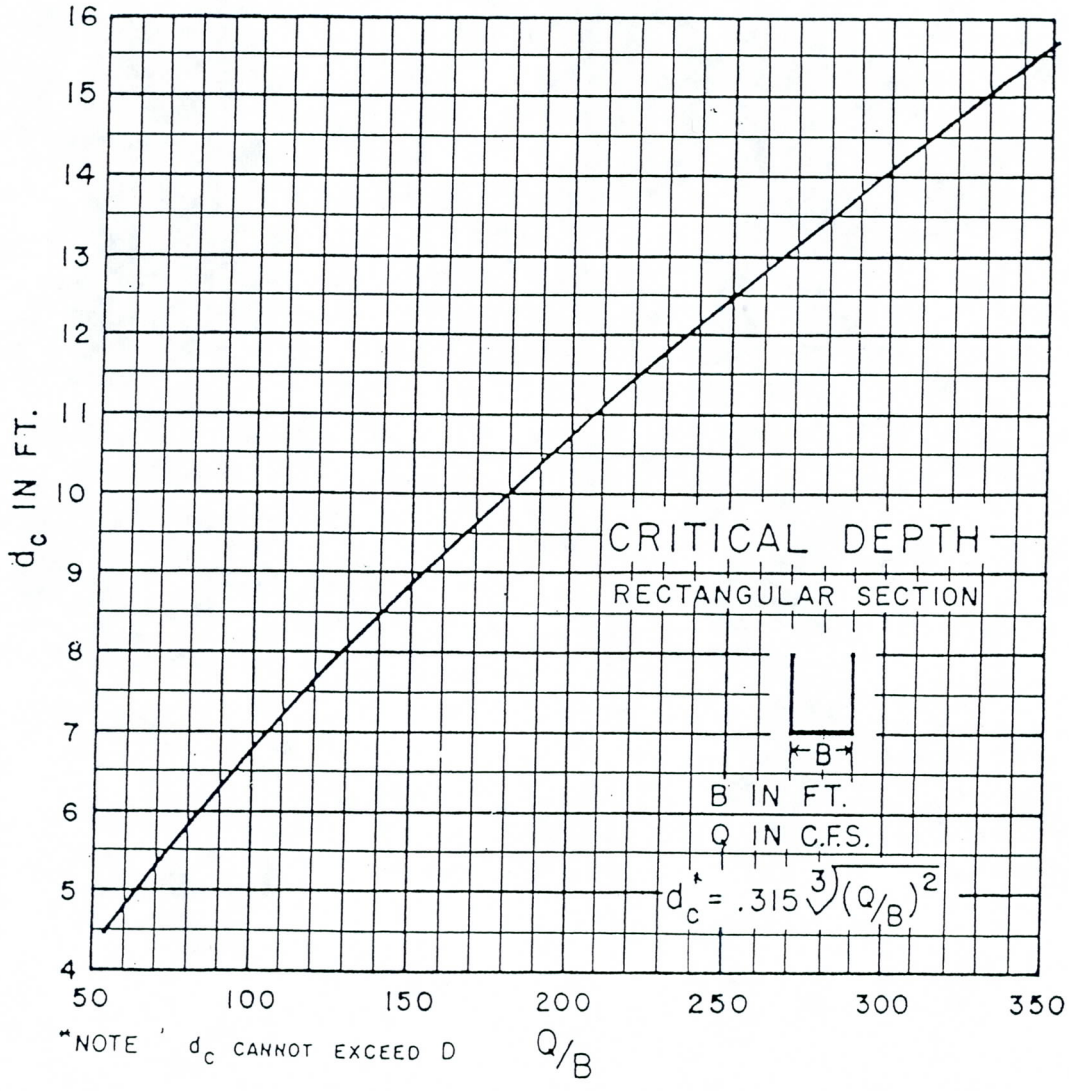
HEAD FOR
CONCRETE BOX CULVERTS
FLOWING FULL
n = 0.012

BUREAU OF PUBLIC ROADS JAN. 1963

Culvert 70 - O

CHART 15





*NOTE ' d_c CANNOT EXCEED D

BUREAU OF PUBLIC ROADS JAN 1963

SVERDRUP

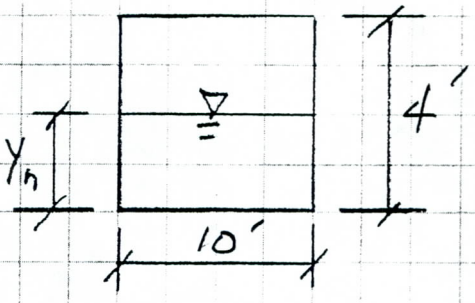
JOB 40477 Toyota SHEET NO. 5 OF

COMPUTATIONS FOR Culvert 70-0 DATE 7/18/91

BY BDO CHKD RJT

Check depth of Flow using Manning Eqn.

$Q100 = 938$ cfs $Q/barrel = 938/2 = 469$ cfs



$n = 0.012$

$S_o = 0.0050$ ft/ft

$Y_n \sim 3.36'$

$A = 33.6$ ft^2

$WP = 2(3.36) + 10 = 16.72'$

$R_h = A/WP = 33.60/16.72 = 2.0096'$

$$V = \frac{1.49}{.012}(2.0096)^{.666}(.005)^{.5} = 13.98 \text{ fps}$$

Check

$Q = VA = 13.98(33.6) = 470$ cfs (OK)

Check Froude Number

$$F = \frac{V}{\sqrt{g \times Y_n}} = \frac{13.98}{\sqrt{32.2 \times 3.36}} = 1.34$$, Supercritical

$Q10 = 392$ cfs , 196 cfs/barrel

$Y_n = 1.84'$, Velocity = 10.67 fps, $F = 1.39$

SVERDRUP

JOB 40477 Toyota

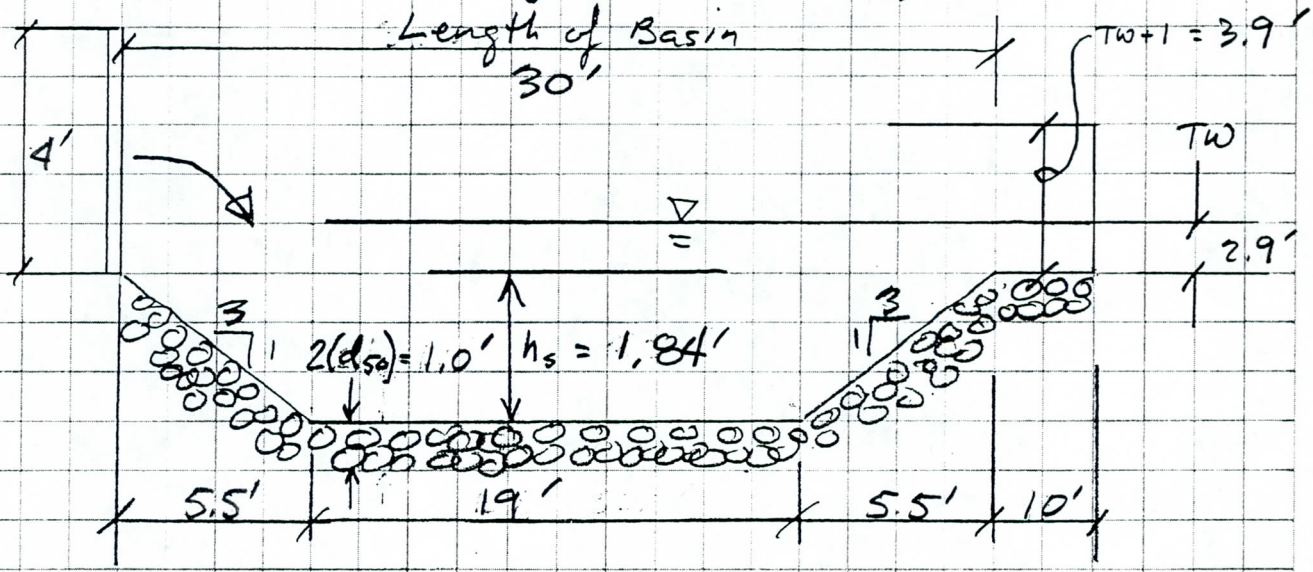
COMPUTATIONS FOR Box Culvert 70-0

SHEET NO. 6 OF

DATE 7/18/91

BY BDO CHKD RJT

Riprap Plunge Basin Design (Q10)



Check Rock Size (From Figure XI-2, HEC No. 14)

For $y_o = 1.84'$ $d_{50} = 6''$ or $0.50'$

$d_{50}/y_o = \frac{0.50'}{1.84'} = 0.27$, $F = 1.39$

$\frac{h_s}{y_o} = 1.05$ $h_s = 1.05\,(1.84') = 1.93'$

Check $\frac{h_s}{d_{50}} = \frac{1.93'}{0.50} = 3.86 < 4$ and > 2

Length of Basin

$10\,h_s = 10\,(1.93) = 19.3'$

or

$3(W_o) = 3(10) = 30'$

Use 30'

Culvert 70-0

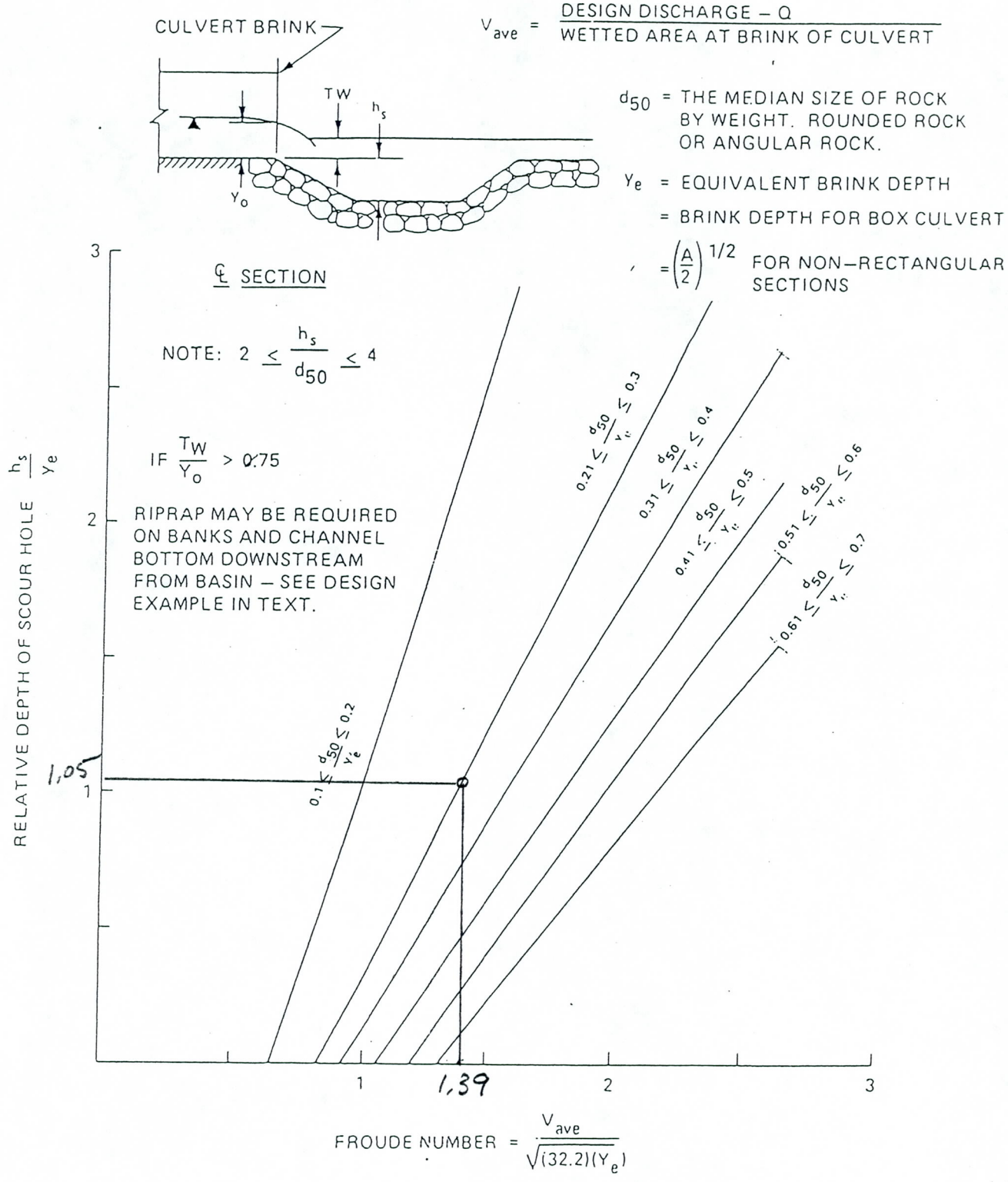


FIGURE X1–2. RELATIVE DEPTH OF SCOUR HOLE VERSUS FROUDE NUMBER AT BRINK OF CULVERT WITH RELATIVE SIZE OF RIPRAP AS A THIRD VARIABLE

SVERDRUP

JOB 40477 Toyota SHEET NO. 8 OF

COMPUTATIONS FOR Box Culvert 70 0 DATE 7/18/91

BY BDO CHKD RJT

$TW/Y_o = \frac{2.9'}{1.84'} = 1.58 > 0.75$ ∴ Check downstream riprap lining for channel protection.

Utilize figure XI-3 for existing average velocity along channel. Compute equivalent circular diameter. D_e for brink area from:

$A = \pi D_e^2/4 = Y_o(W_o) = 1.84(10) = 18.4 ft^2$

$D_e = (18.4(4)/\pi)^{1/2} = 4.84$

From downstream cross section Q10 velocity is 7.9 fps. Culvert outlet velocity is 10.7 fps.

L/D_e	L	V_L/V_o	V_L	
6	29.0'	.82	8.8	
7	33.9'	.77	8.2	
8	38.7'	.72	7.7	ok

∴ Need riprap lining for approximately 38 feet from the end of the culvert outlet apron. This is less than the 40 feet designed. Thus design is ok.

SVERDRUP

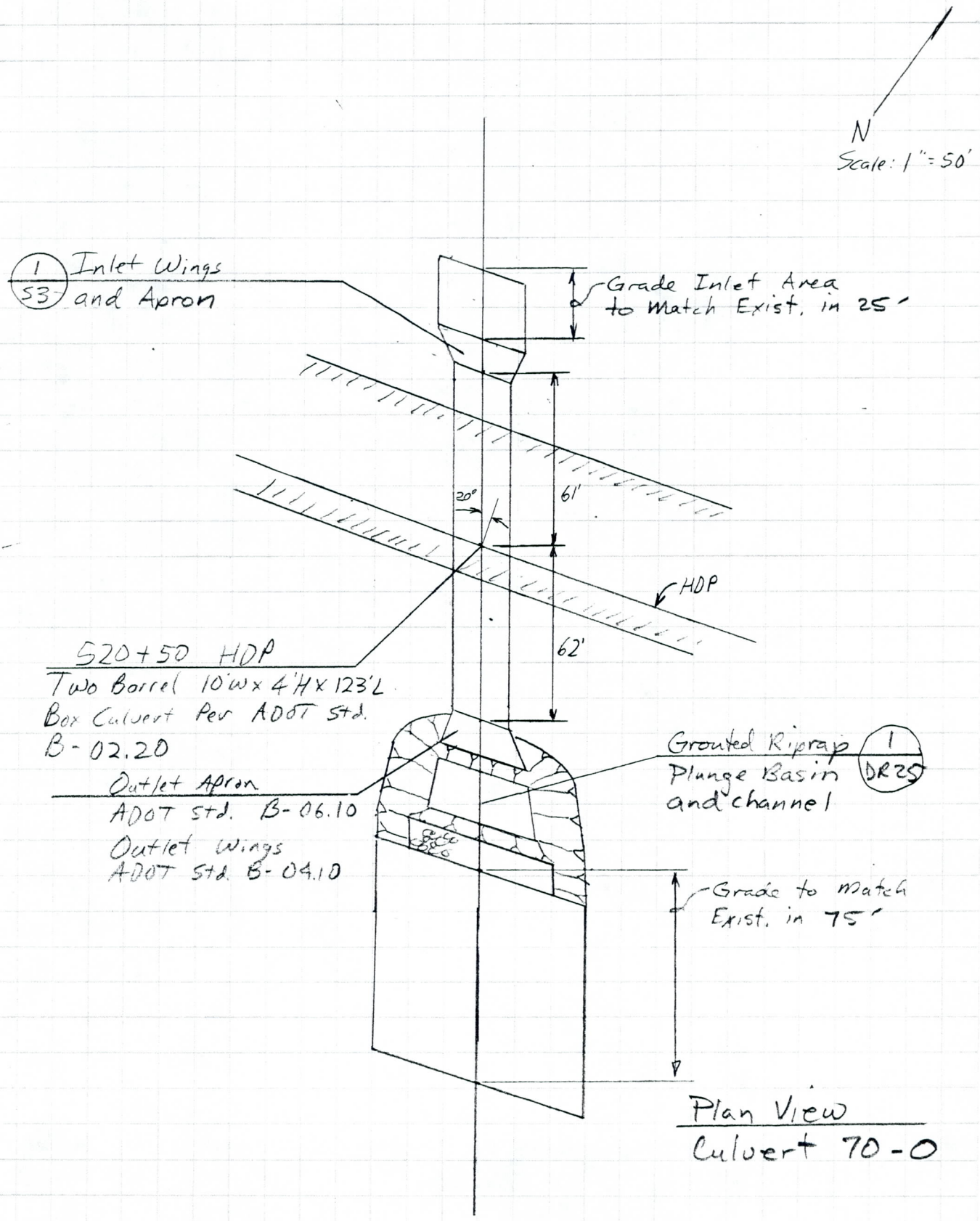
JOB 40477 Toyota

SHEET NO. 9 OF

DATE 7-16-91

COMPUTATIONS FOR Culvert 70-0 Plan View BY BDO CHKD RJT

HST Sta 520+50 31



Plan View

Culvert 70-0

SVERDRUP

JOB 40422 Toyota

COMPUTATIONS FOR Culvert 70-0 31

HST Sta. 520+50

SHEET NO. 10 OF

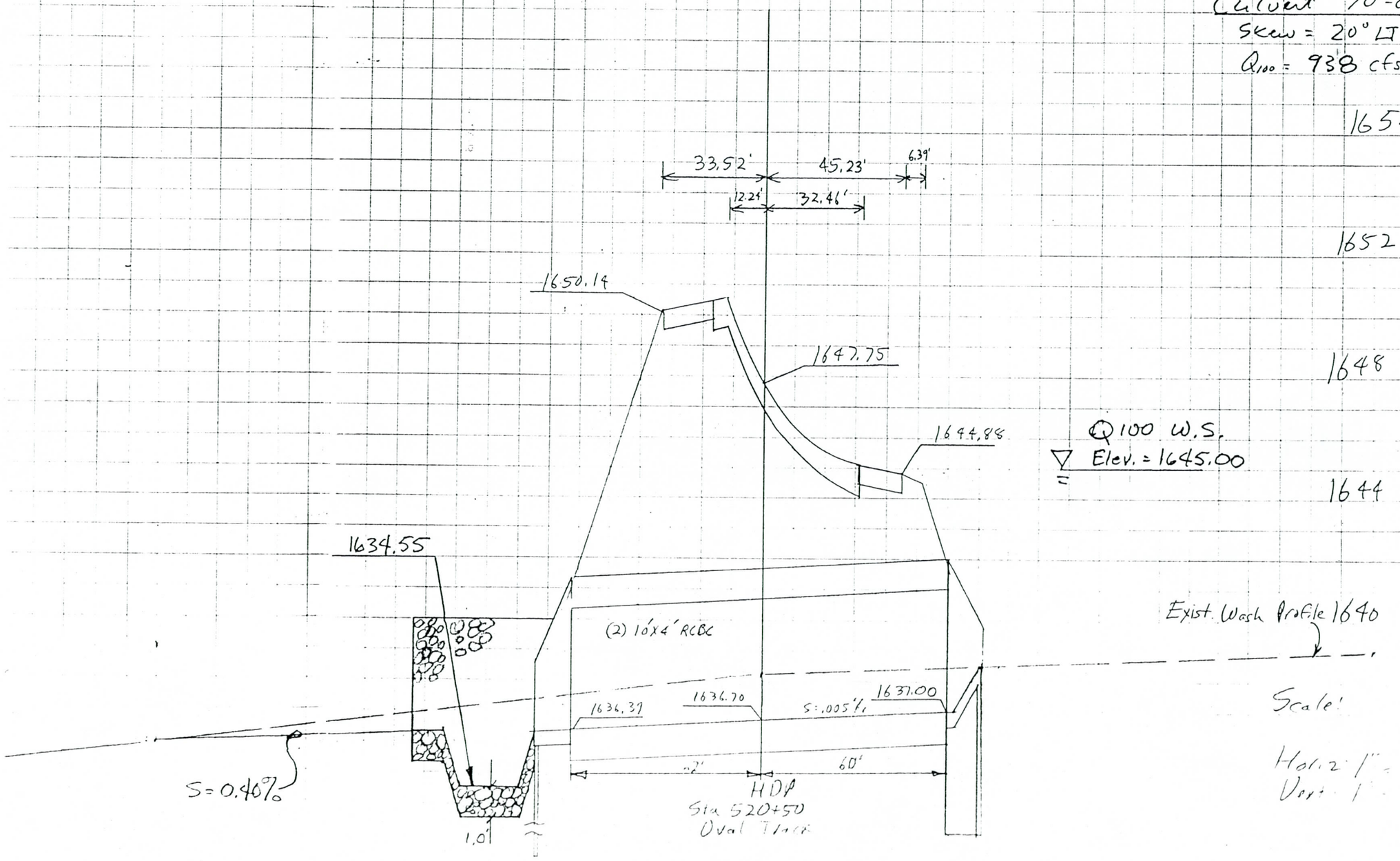
DATE 7-13-9

BY BDO CHKD RTT

Culvert 70-0 31

Skew = 20° LT

Q_{100} = 938 cfs



SECTION NUMBER TW70O 7/18/91

Channel Slope: 0.0108 ft./ft.

CROSS SECTION DATA:

OFFSET	53	126	141.1	149.7	156.1	194.6	201.7	237	245.1	252.3	272.1
ELEV.	42.48	43.4	35.95	36.23	38.83	38.39	40.62	41.17	39.78	40.87	41.57
N	N/A	0.035	0.035	0.025	0.035	0.035	0.035	0.035	0.035	0.035	0.035

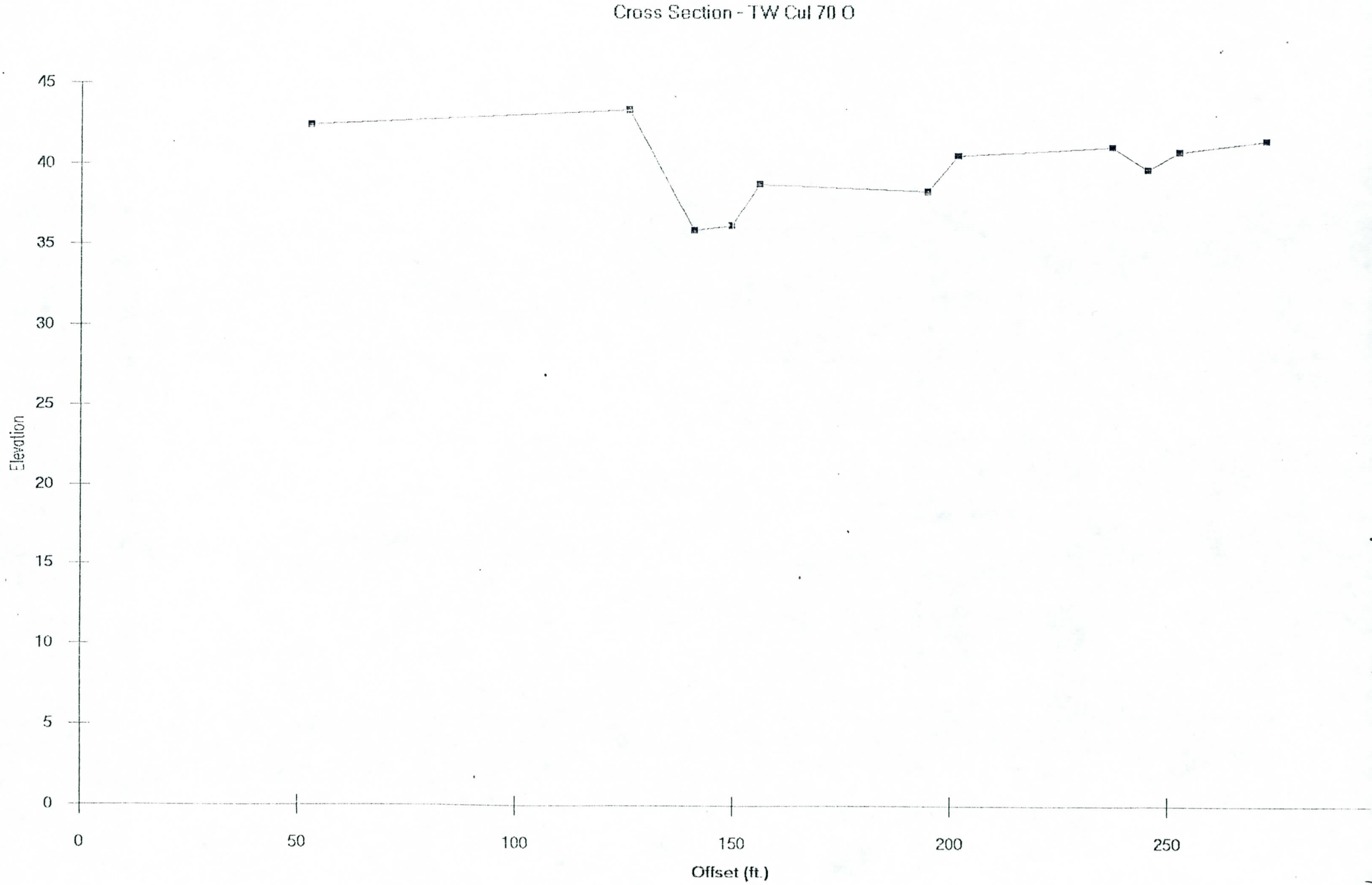
STAGE-DISCHARGE DATA:

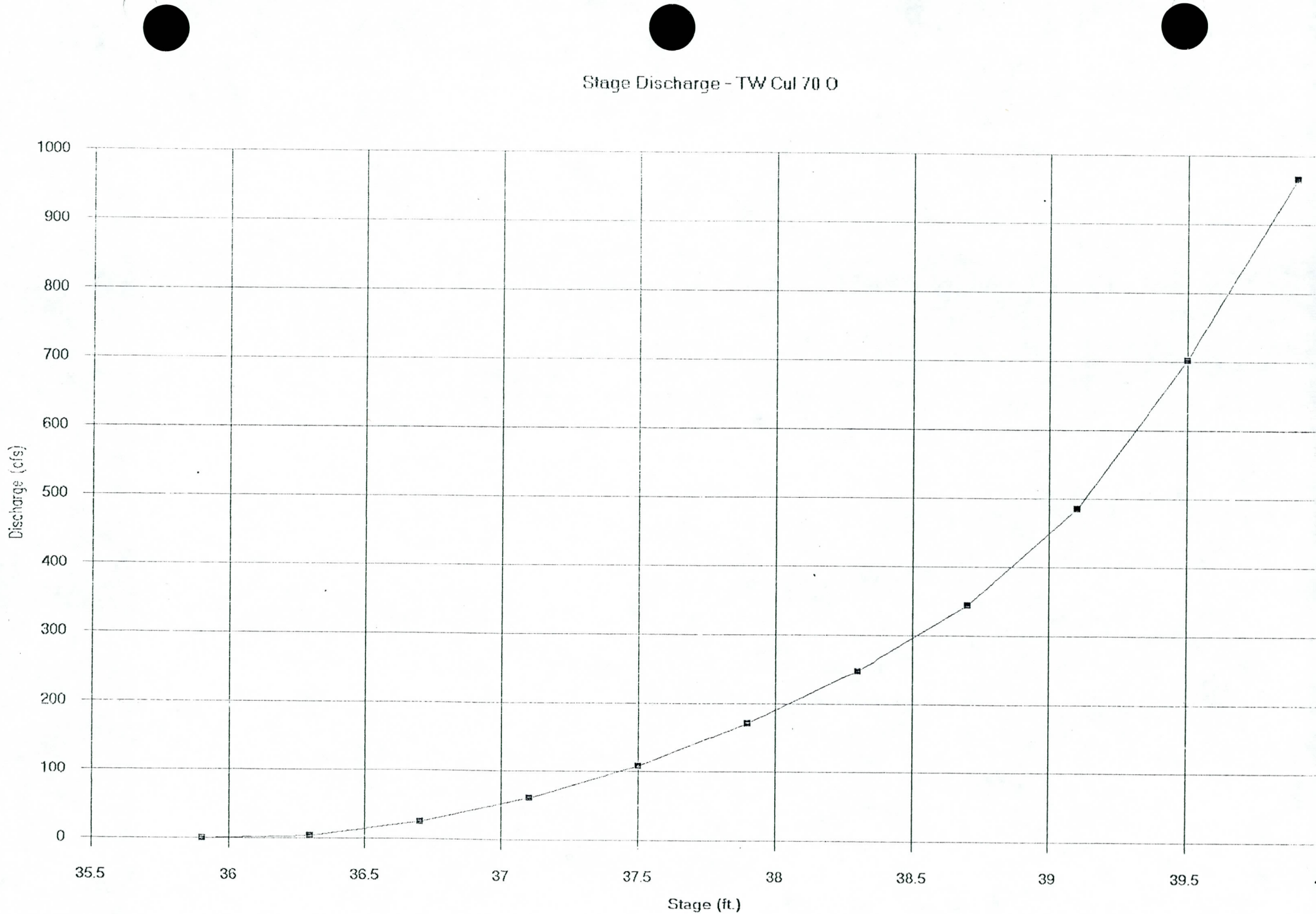
STAGE:	35.9													
WET PER.		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
AREA		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYD.RAD.		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Q		0	0	0	0	0	0	0	0	0	0	0	0	0
STAGE:	36.3													
WET PER.		0.0	0.8	8.6	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
AREA		0.0	0.1	1.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYD.RAD.		0.0	0.2	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Q		0	0	4	0	0	0	0	0	0	0	0	0	0
STAGE:	36.7													
WET PER.		0.0	1.7	8.6	1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
AREA		0.0	0.6	5.2	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYD.RAD.		0.0	0.3	0.6	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Q		0	1	23	0	0	0	0	0	0	0	0	0	0
STAGE:	37.1													
WET PER.		0.0	2.6	8.6	2.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
AREA		0.0	1.3	8.7	0.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYD.RAD.		0.0	0.5	1.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Q		0	4	54	2	0	0	0	0	0	0	0	0	0
STAGE:	37.5													
WET PER.		0.0	3.5	8.6	3.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
AREA		0.0	2.4	12.1	2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYD.RAD.		0.0	0.7	1.4	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Q		0	8	94	6	0	0	0	0	0	0	0	0	0
STAGE:	37.9													
WET PER.		0.0	4.4	8.6	4.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
AREA		0.0	3.9	15.6	3.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYD.RAD.		0.0	0.9	1.8	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Q		0	16	143	13	0	0	0	0	0	0	0	0	0

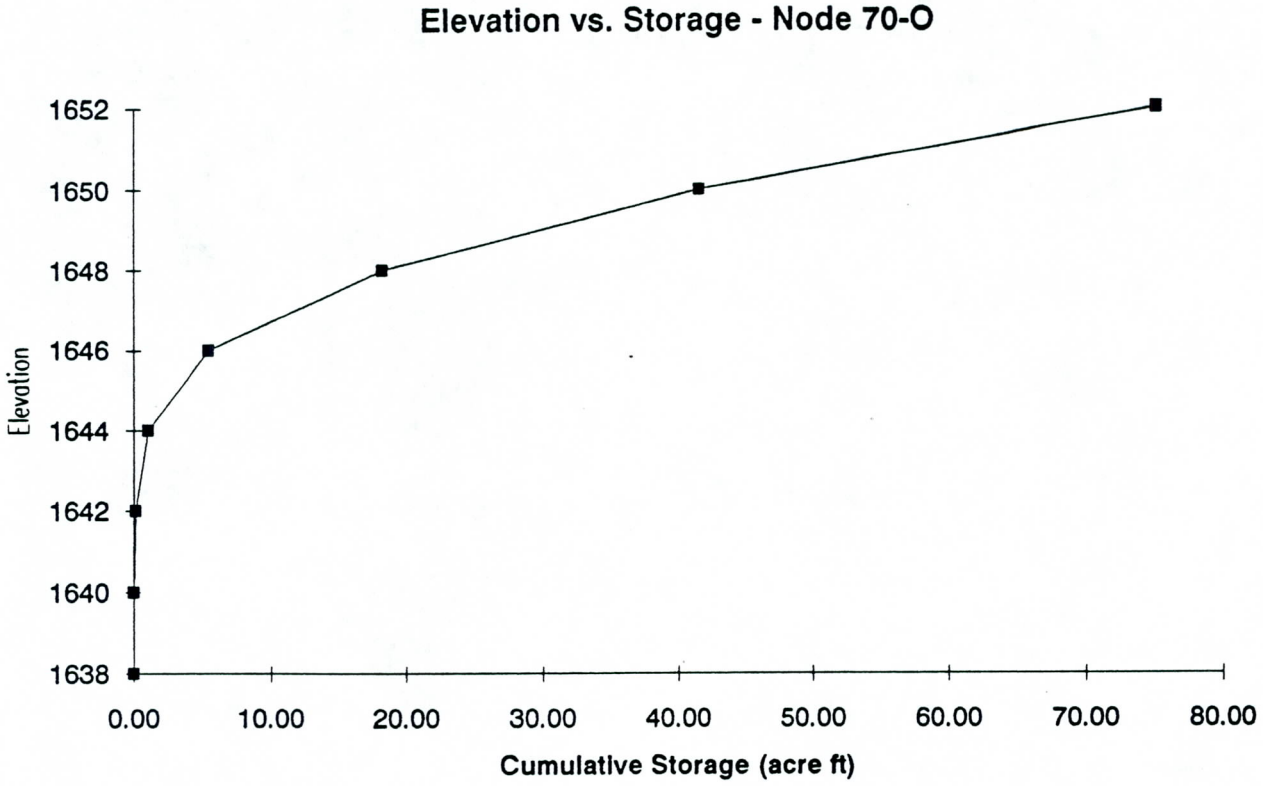
SECTION NUMBER TW70O 7/18/91

STAGE:	38.3													
WET PER.		0.0	5.3	8.6	5.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
AREA		0.0	5.6	19.0	5.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYD.RAD.		0.0	1.1	2.2	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Q		0	26	199	23	0	0	0	0	0	0	0	0	0
STAGE:	38.7													
WET PER.		0.0	6.2	8.6	6.6	27.1	28.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
AREA		0.0	7.7	22.4	7.5	4.2	4.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYD.RAD.		0.0	1.2	2.6	1.1	0.2	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Q		0	39	263	36	0	6	0	0	0	0	0	0	0
STAGE:	39.1													
WET PER.		0.0	7.1	8.6	6.9	45.4	47.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0
AREA		0.0	10.1	25.9	10.0	28.9	29.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYD.RAD.		0.0	1.4	3.0	1.5	0.6	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Q		0	56	333	0	0	96	0	0	0	0	0	0	0
STAGE:	39.5													
WET PER.		0.0	8.0	8.6	6.9	45.4	49.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
AREA		0.0	12.8	29.3	12.6	46.9	48.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYD.RAD.		0.0	1.6	3.4	1.8	1.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Q		0	77	410	0	0	215	0	0	0	0	0	0	0
STAGE:	39.9													
WET PER.		0.0	8.9	8.6	6.9	45.4	50.5	0.0	0.7	1.5	0.0	0.0	0.0	0.0
AREA		0.0	15.8	32.8	15.2	64.8	68.5	0.0	0.0	0.1	0.0	0.0	0.0	0.0
HYD.RAD.		0.0	1.8	3.8	2.2	1.4	1.4	0.0	0.1	0.1	0.0	0.0	0.0	0.0
Q		0	102	494	0	0	370	0	0	0	0	0	0	0

W.S. Elev.	35.9	36.3	36.7	37.1	37.5	37.9	38.3	38.7	39.1	39.5	39.9
Q	0	4	25	60	109	171	247	344	485	702	966
A	0.0	1.9	6.1	11.0	16.5	22.9	29.9	42.0	65.7	90.9	117.1
V	0.0	2.1	4.1	5.5	6.6	7.5	8.3	8.2	7.4	7.7	8.3


Cross Section - TW Cul 70 O
45
40
35
30
25
20
15
10
5
0
Elevation
0
50
100
150
200
250
Offset (ft.)


Stage Discharge - TW Cul 70 O
1000
900
800
700
600
500
400
300
200
100
0
Discharge (cfs)
35.5
36
36.5
37
37.5
38
38.5
39
39.5
Stage (ft.)


Elevation vs. Storage - Node 70-O
1652
1650
1648
1646
1644
1642
1640
1638
Elevation
0.00
10.00
20.00
30.00
40.00
50.00
60.00
70.00
80.00
Cumulative Storage (acre ft)

JOB 40 Toyota

COMPUTATIONS FOR Culvert 70 M-1 | 32

SHEET NO ____ OF ____

DATE 2/6/91

BY BDO CHKD RJT

CULVERT COMPUTATION SHEET

PROJECT: ____

STATION: 21+00, Ramp A

DESIGNER: ____

DATE: ____

HYDROLOGIC AND CHANNEL INFORMATION

DRAINAGE AREA 0.08 Sq miles

Q_1 = 23cfs

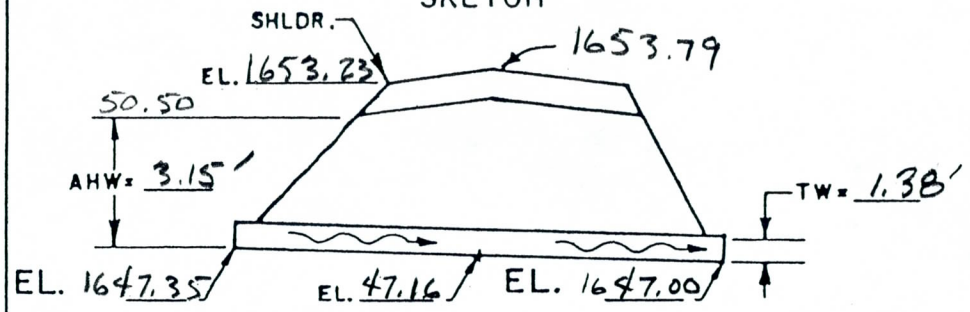
Q_2 = ____

TW_1 = 1.38' New Channel

TW_2 = ____

(Q_1 = DESIGN DISCHARGE, SAY Q_{25})
(Q_2 = CHECK DISCHARGE, SAY Q_{50})

SKETCH



S_o = .005' L = 70' L/100 S_o = ____

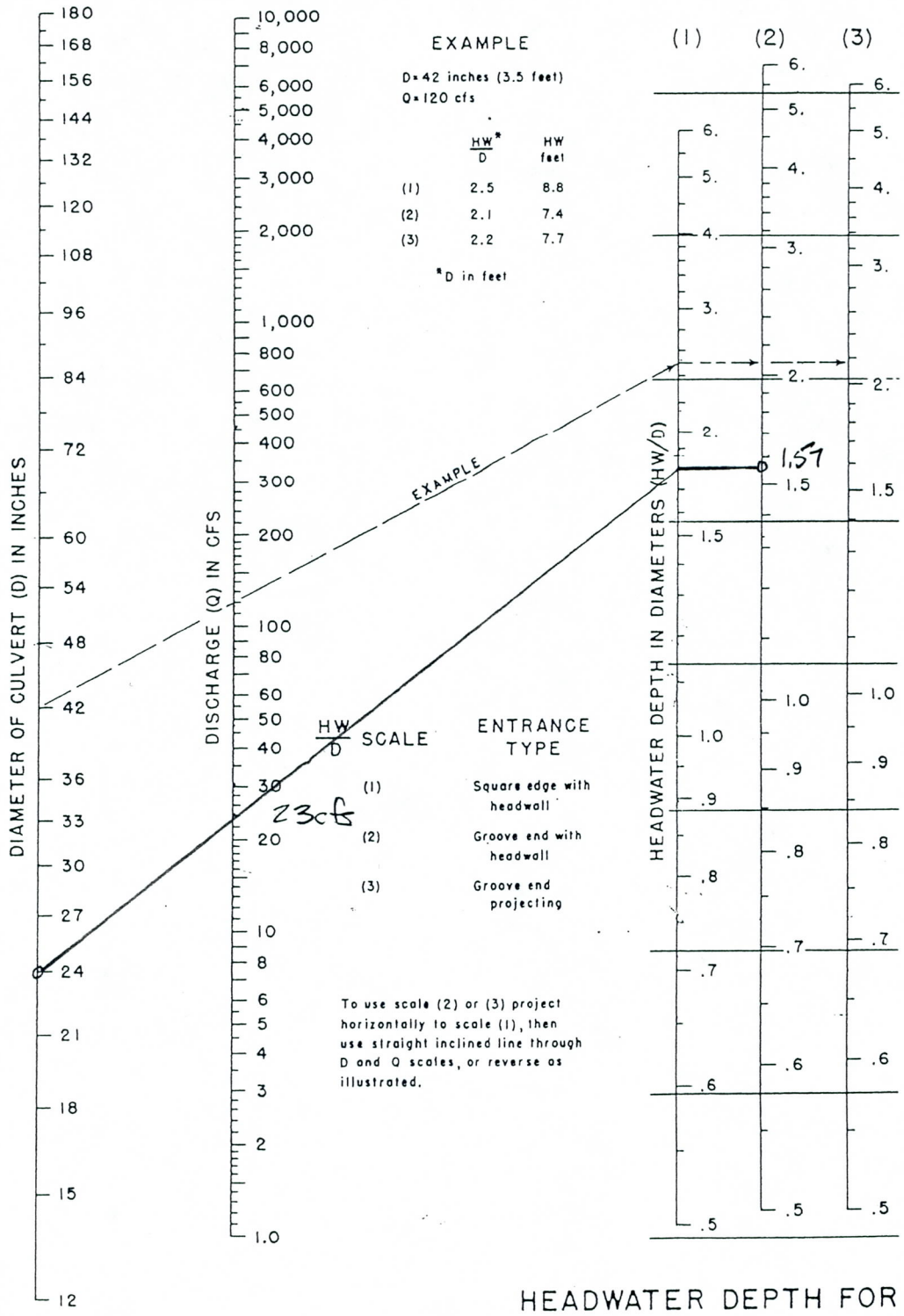
MEAN STREAM VELOCITY = 2.4 fps

CULVERT DESCRIPTION		Q	CAP. CHART HW	HEADWATER COMPUTATION										CONTROL HW	OUTLET VELOCITY	COST	DHW ELEV.	COMMENTS
				INLET CONT.		OUTLET CONTROL $HW = H + h_o - LS_o$												
SIZE	ENTR. TYPE			HW/D	HW	K_e	H	d_c	$\frac{d_c + D}{2}$	TW	H_o	LS_o	HW					
(1) 24" RCP	Headwall	23		1.575	3.15	0.2	1.65	1.70	1.85	1.38	1.85	0.35	3.15	3.15	8.1		1650.50	Inlet/Outlet Control

SUMMARY & RECOMMENDATIONS Use riprap outlet protection for downstream channel.

Culvert 70 M-1

CHART 2

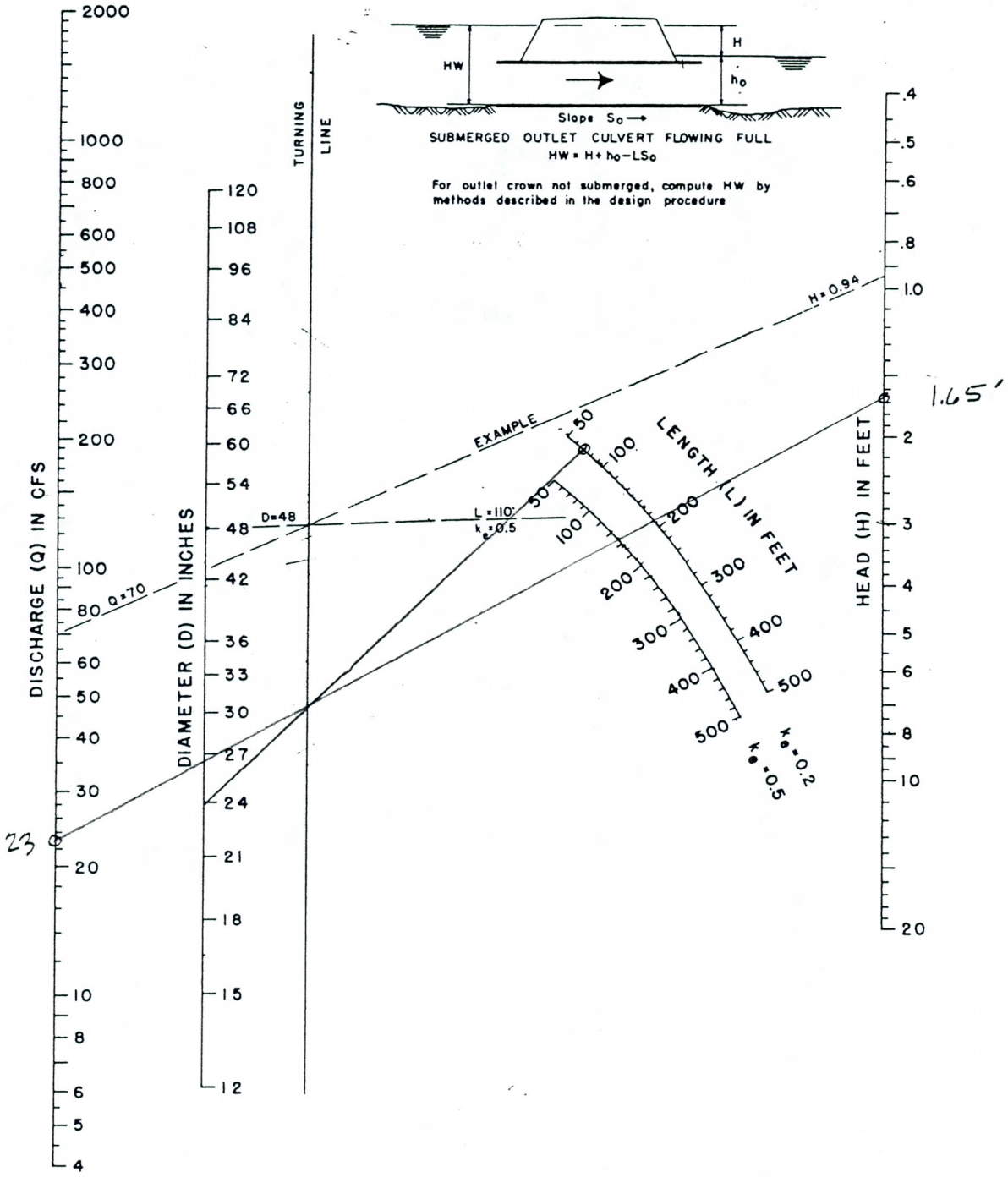


HEADWATER DEPTH FOR CONCRETE PIPE CULVERTS WITH INLET CONTROL

BUREAU OF PUBLIC ROADS JAN. 1963

Culvert 70 M-1

CHART 9

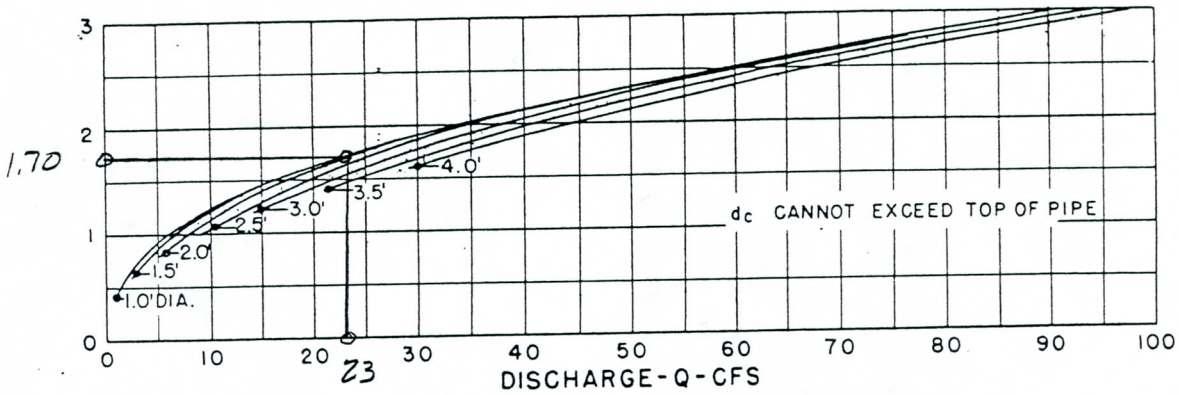


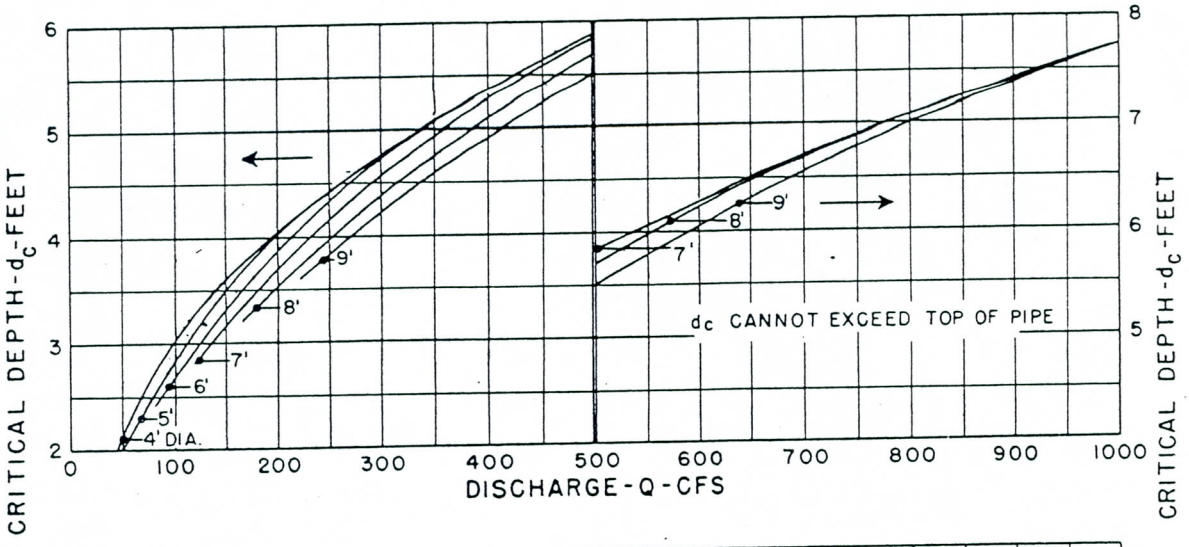
HEAD FOR
CONCRETE PIPE CULVERTS
FLOWING FULL
n = 0.012

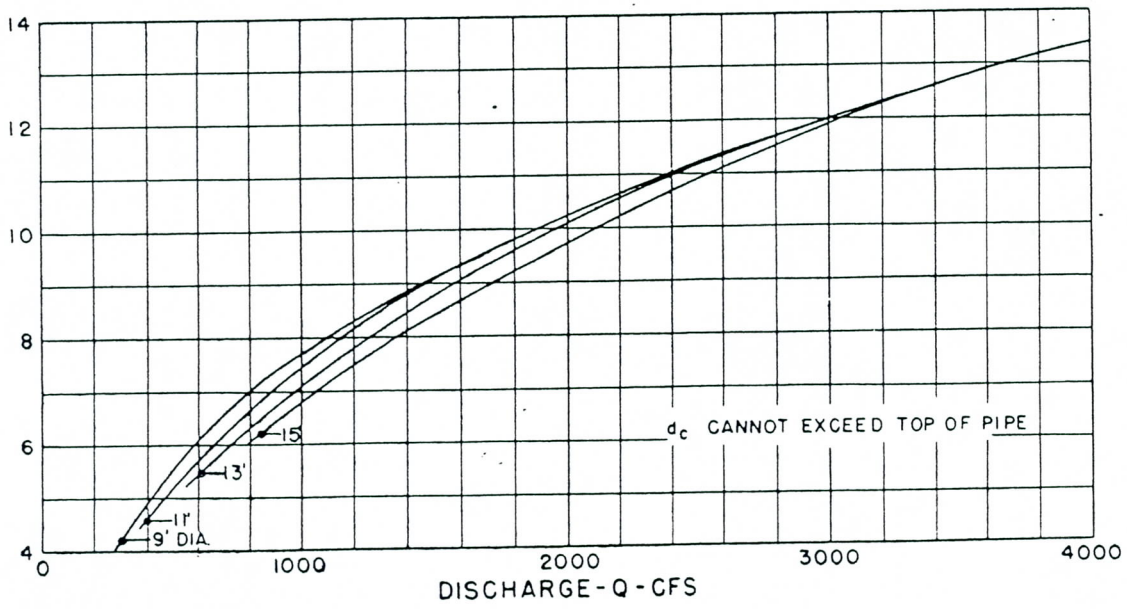
BUREAU OF PUBLIC ROADS JAN. 1963

Culvert 70 M-1

CHART 16







BUREAU OF PUBLIC ROADS

JAN. 1964

CRITICAL DEPTH CIRCULAR PIPE

SVERDRUP

JOB 40477 Toyota SHEET NO. 5 OF

COMPUTATIONS FOR Culvert 70 M-1 DATE 7/26/91

BY BDO CHKD RJT

Check outlet velocity for 24" Pipe

$Q100 = 23$ cfs $\quad n = 0.013 \quad d = 2.0'$ $\quad S = 0.0050'/'$

$$K' = \frac{Qn}{d^{8/3} S^{1/2}} = \frac{23(.013)}{(2)^{8/3}(.005)^{1/2}} = 0.67$$ (Beyond limits of Open Channel Flow ∴ Pipe Full)

$$V = Q/A = \frac{23 \text{ cfs}}{3.142 \text{ ft}^2} = 7.32 \text{ fps (Inlet Control)}$$

Check Froude Number

$$F = \frac{V}{\sqrt{g\, Y_o}} = \frac{7.32}{\sqrt{32.2\,(2)}} = 0.91$$

Use dumped riprap to line channel area around the culvert for erosion control.

During outlet control:

$D = 2' > TW = 1.38' < d_c = 1.70'$ ∴ d_c controls

$$\frac{d_c}{D} = \frac{1.70'}{2'} = 0.85 \Rightarrow \frac{A}{D^2} = 0.7115 \Rightarrow A = D^2(.7115)$$

$A = (2)^2(.7115) = 2.85 \text{ ft}^2 \quad V = \frac{Q}{A} = \frac{23}{2.85} = 8.07 \text{ fps}$

∴ Outlet Control is the Controlling Velocity

SVERDRUP

JOB 40477 Toyota

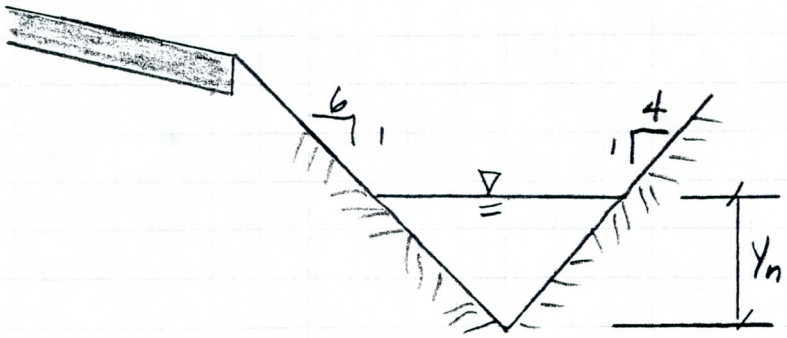
COMPUTATIONS FOR Tailwater 70 M-1

SHEET NO. 6 OF

DATE 7/26/91

BY BDO CHKD RJT

Check tailwater Depth for channel downstream of 24" RCP Culvert.



$Q_{100} = 23$ cfs

$n = 0.03$

$S_o = 0.0040$ ft/ft

$Y_n \sim 1.38'$

$A = \frac{1}{2}(1.38^2 \times 6) + \frac{1}{2}(1.38^2 \times 4) = 9.52 \text{ ft}^2$

$WP = 8.39 + 5.69 = 14.08'$

$R_h = A/WP = 9.52/14.08 = 0.6761$ ft

$V = \frac{1.49}{.03}(.6761)^{.666}(.004)^{.5} = 2.42$ fps

Check

$Q = VA = 2.42(9.52) = 23$ cfs (OK)

SVERDRUP

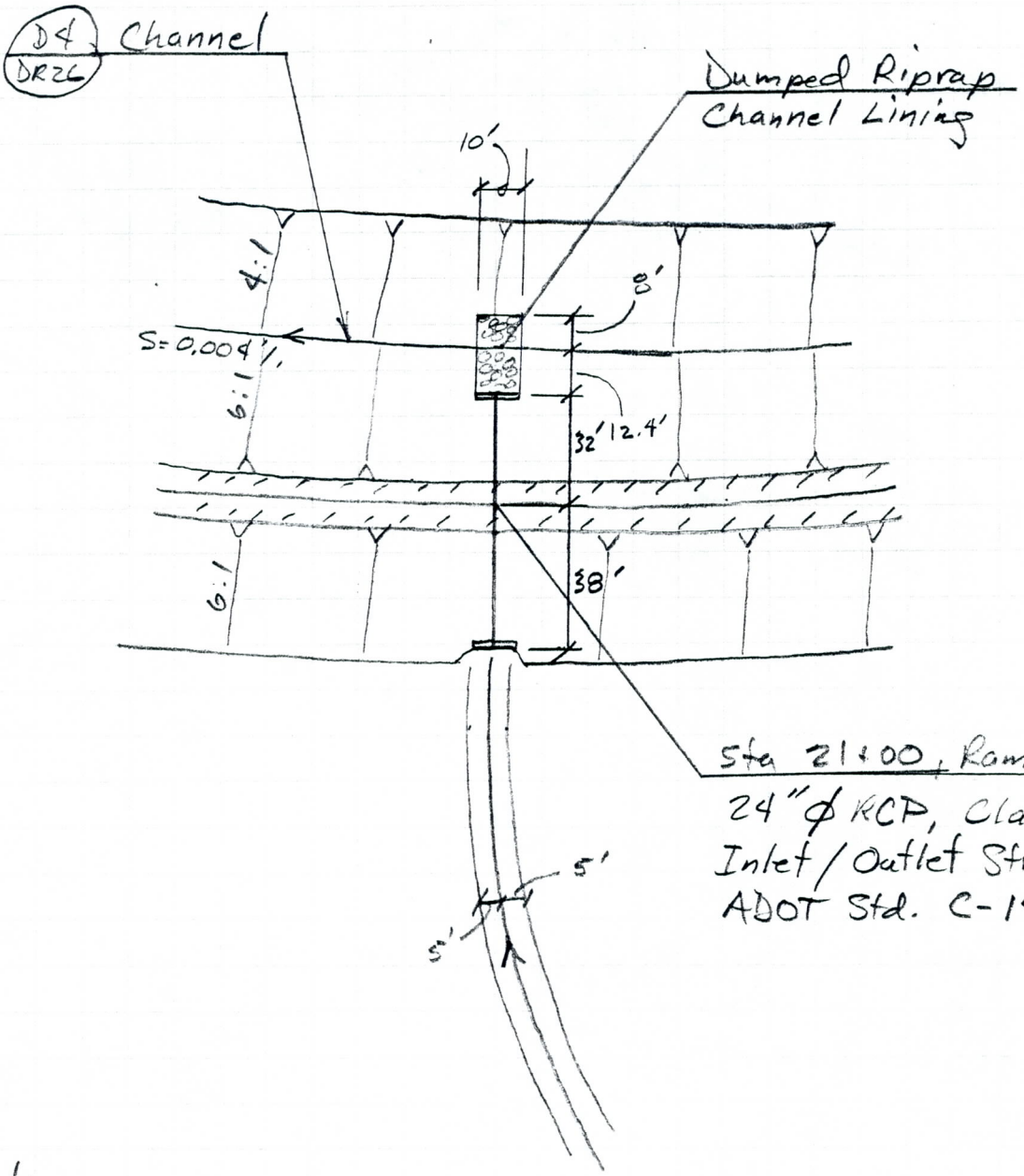
JOB 40477 Toyota

COMPUTATIONS FOR Culvert 70 M-1 [32] Plan View

SHEET NO. 7 OF

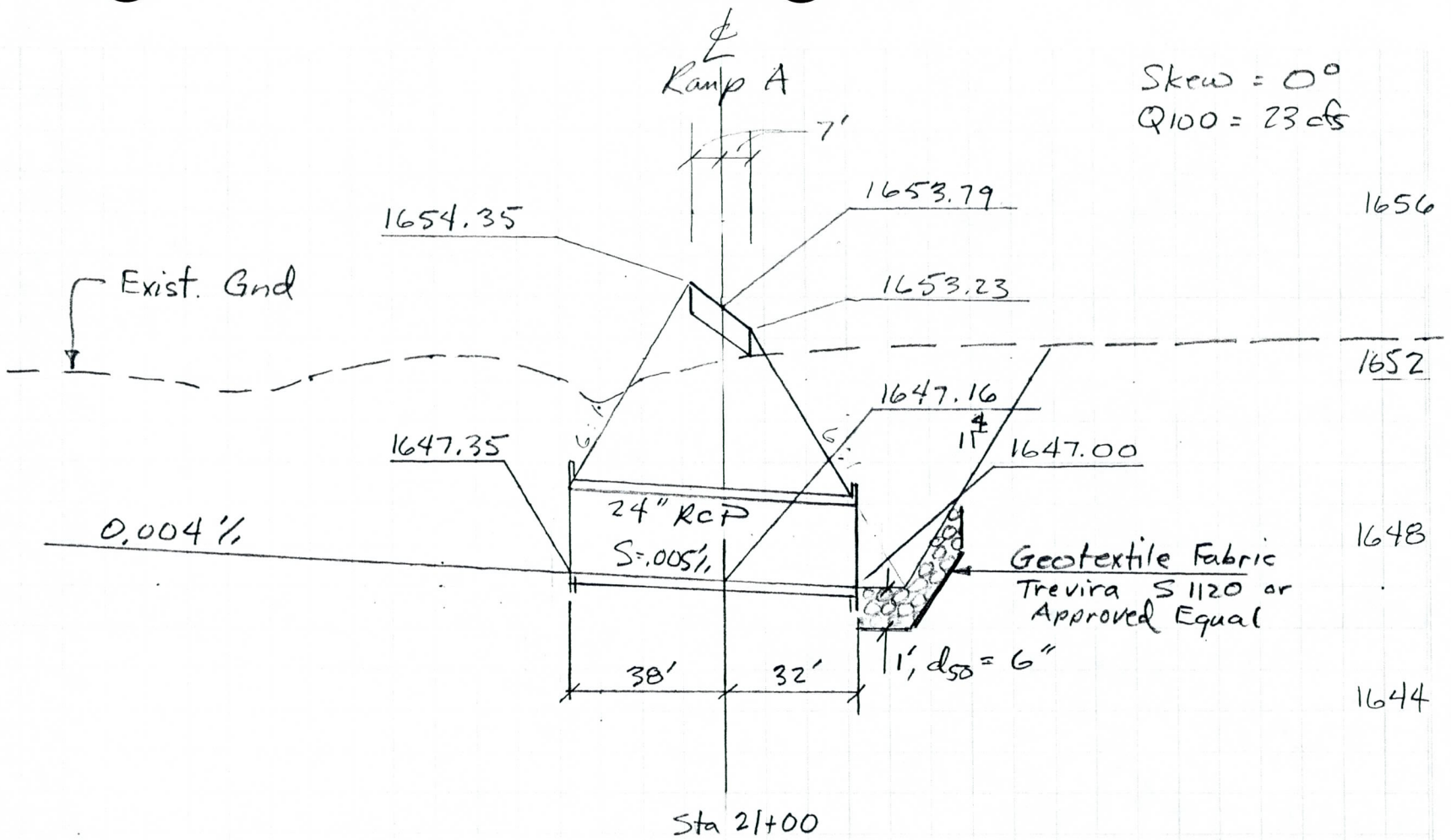
DATE 7/26/91

BY BDO CHKD RJT



Scale
Horizontal 1" = 50'

32 Pipe Culvert
Sta 21+00, Ramp A
See Profile DWG DR14



Skew = 0°
Q100 = 23 cfs

SVERDRUP

JOB 40477 Toyota
COMPUTATIONS FOR Culvert 70 M-1 32
SHEET NO. 8 OF
DATE 7/25/94
BY BDD CHKD RJT

32 Pipe Culvert
Sta 21+00, Ramp A

Scale
Horiz. 1" = 40'
Vert. 1" = 4'

JOB 404 Toyota

COMPUTATIONS FOR Culvert 70 M-2 [33]

SHEET NO 1 OF

DATE 5/91

BY BDO CHKD RJT

CULVERT COMPUTATION SHEET

PROJECT:

STATION: 19+50 Ramp B

DESIGNER:

DATE:

HYDROLOGIC AND CHANNEL INFORMATION

DRAINAGE AREA 0.08 Sq. Miles

Q_1 = 240 cfs

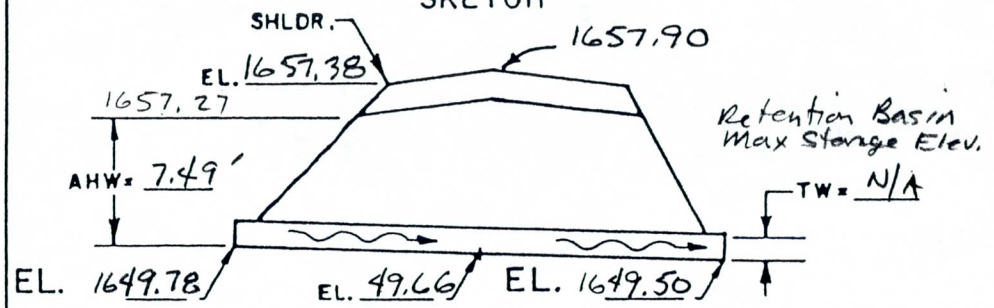
Q_2 = ____

TW_1 = N/A (Retention Basin)

TW_2 = ____

(Q_1 = DESIGN DISCHARGE, SAY Q_{25})
(Q_2 = CHECK DISCHARGE, SAY Q_{50})

SKETCH



S_0 = 0.005 ft/ft L = 56' L/100 S_0 = ____

MEAN STREAM VELOCITY = ____

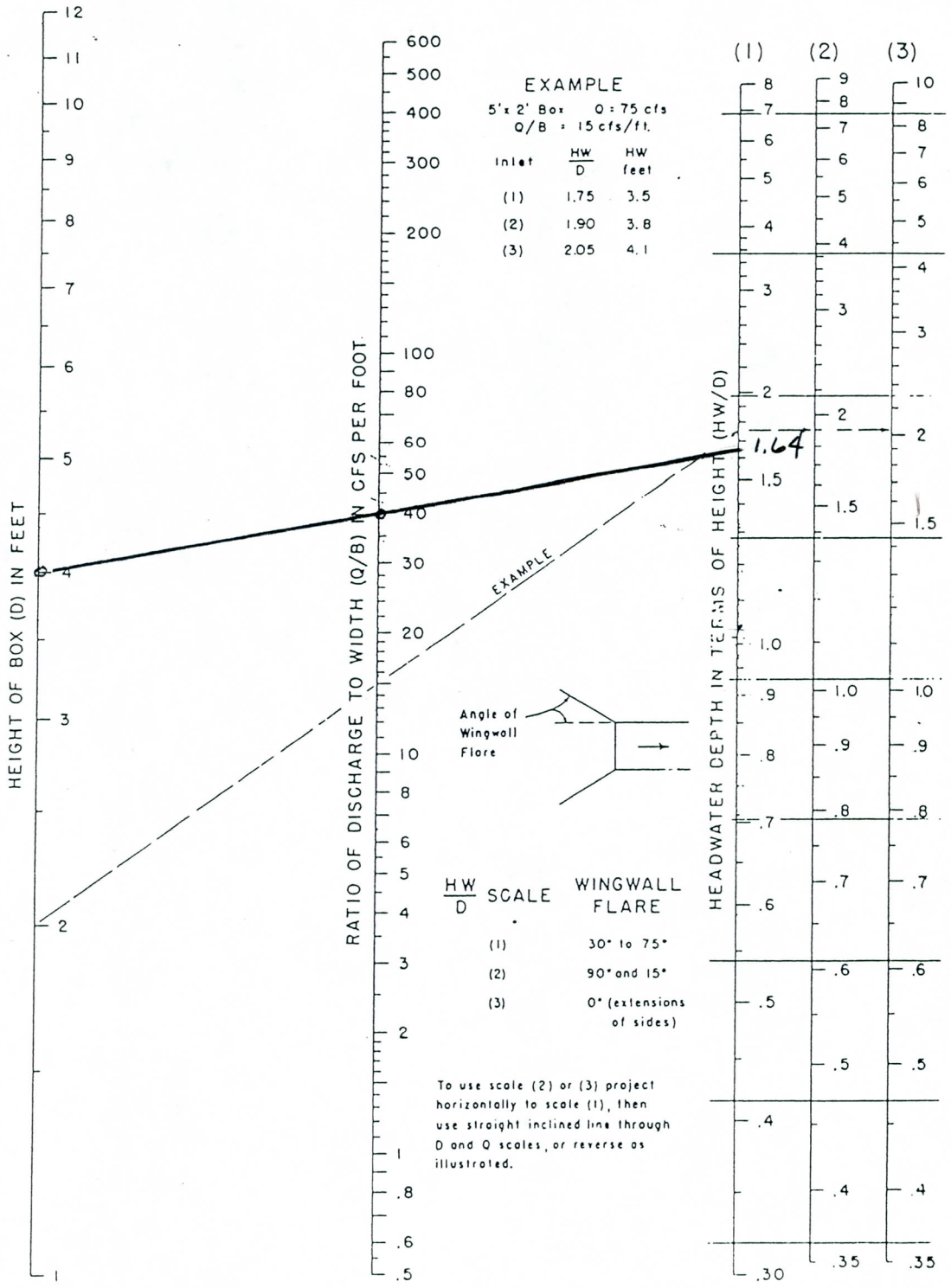
CULVERT DESCRIPTION		Q	CAP. CHART HW	HEADWATER COMPUTATION										CONTROL HW	OUTLET VELOCITY	COST	DHW ELEV.	COMMENTS
				INLET CONT.		OUTLET CONTROL $HW = H + h_o - LS_o$												
SIZE	ENTR. TYPE			$\frac{HW}{D}$	HW	K_e	H	d_c	$\frac{d_c + D}{2}$	TW	h_o	LS_o	HW					
(1) Barrel 10x4	Drop Inlet	240		1.03	4.12	0.2	.76	2.65	3.32	N/A	3.32	.28	3.80	4.12	11.4		1653.90	Inlet Control
(1) Barrel 6x4	Drop Inlet	240		1.64	6.56	0.2	2.2	3.70	3.85	N/A	3.85	.28	5.77	6.56	11.9		1656.34	Inlet Control

SUMMARY & RECOMMENDATIONS Select Single Barrel 6x4 Box Culvert

Culvert 70 M-2

2

CHART I

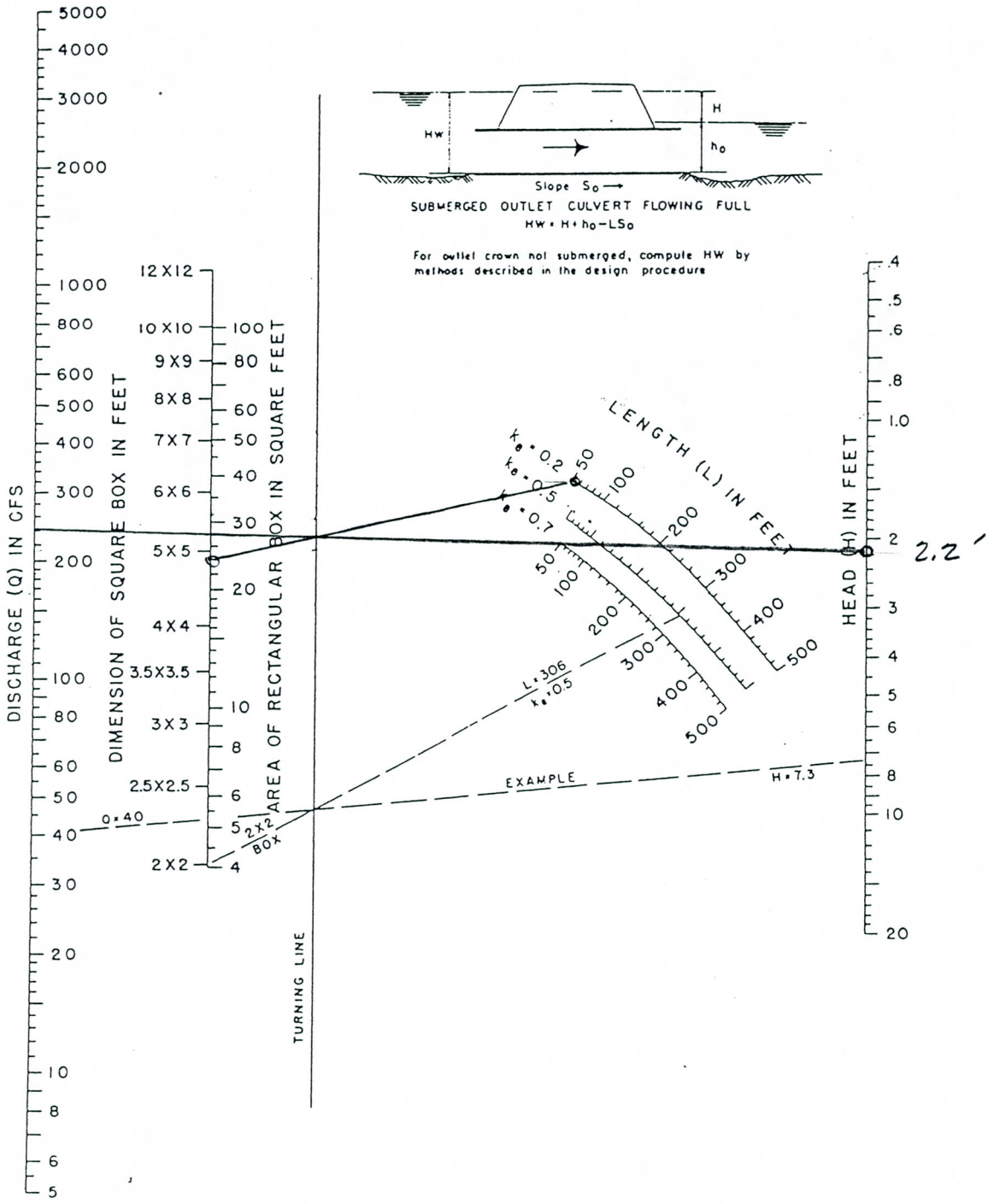


HEADWATER DEPTH FOR BOX CULVERTS WITH INLET CONTROL

BUREAU OF PUBLIC ROADS JAN. 1963

Culvert 70 M-2

CHART 8

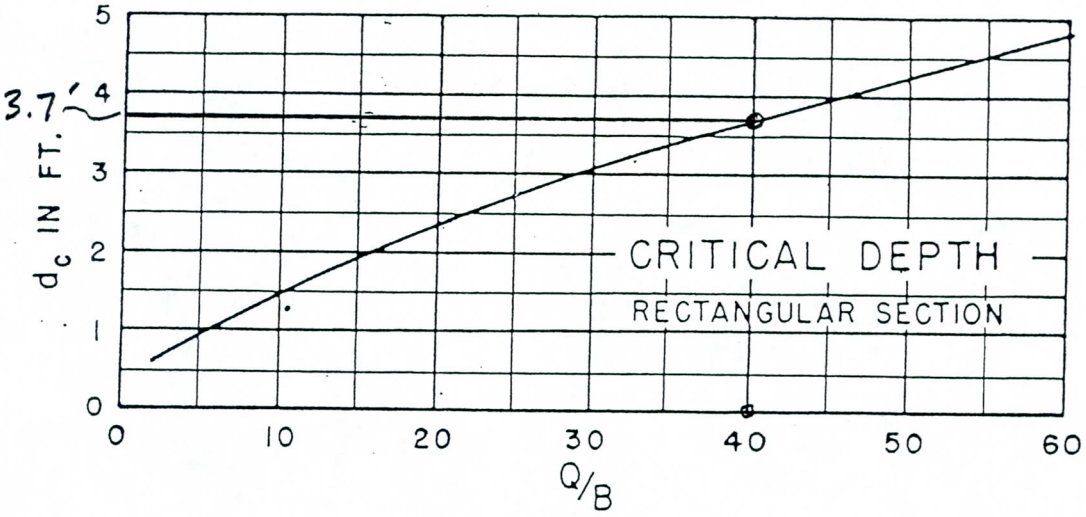


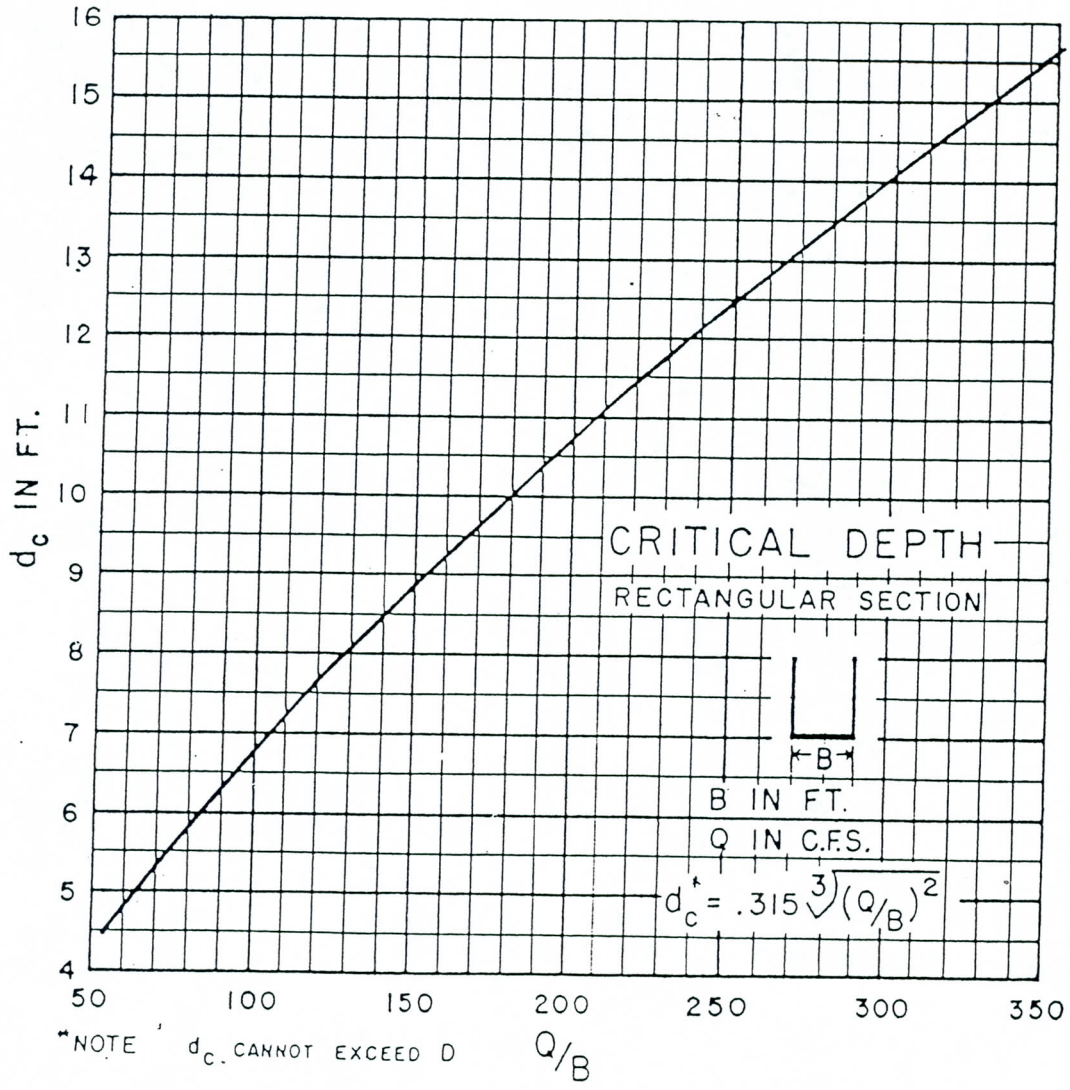
HEAD FOR
CONCRETE BOX CULVERTS
FLOWING FULL
n = 0.012

BUREAU OF PUBLIC ROADS JAN. 1963

Culvert 70 M-2

CHART 15





BUREAU OF PUBLIC ROADS JAN 1963

SVERDRUP

JOB 40477 Toyota

COMPUTATIONS FOR Culvert 70 M-2

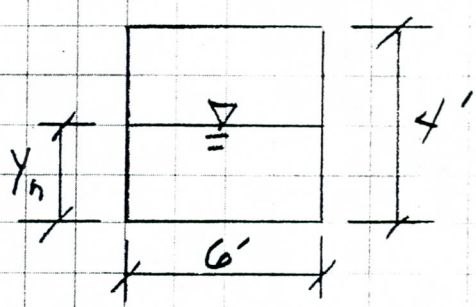
SHEET NO. 5 OF

DATE 7/25/91

BY BDO CHKD RJT

Check depth of Flow using Manning Eqn.

$Q100 = 240$ cfs



$n = 0.012$

$S_o = 0.0050$ ft/ft

$Y_n \sim 3.36'$

$A = 20.16$ ft^2

$WP = 2(3.36) + 6 = 12.72'$

$R_h = A/WP = 20.16/12.72' = 1.5849'$

$$V = \frac{1.49}{.012}(1.5849)^{.666}(.005)^{.5} = 11.93 \text{ fps}$$

Check

$Q = VA = 11.93\ (20.16) = 241$ cfs

Check Froude Number

$$\# = \frac{V}{\sqrt{g \times Y_n}} = \frac{11.93}{\sqrt{32.2 \times 3.36}} = 1.15$$, Supercritical

SVERDRUP

JOB 40477 Toyota

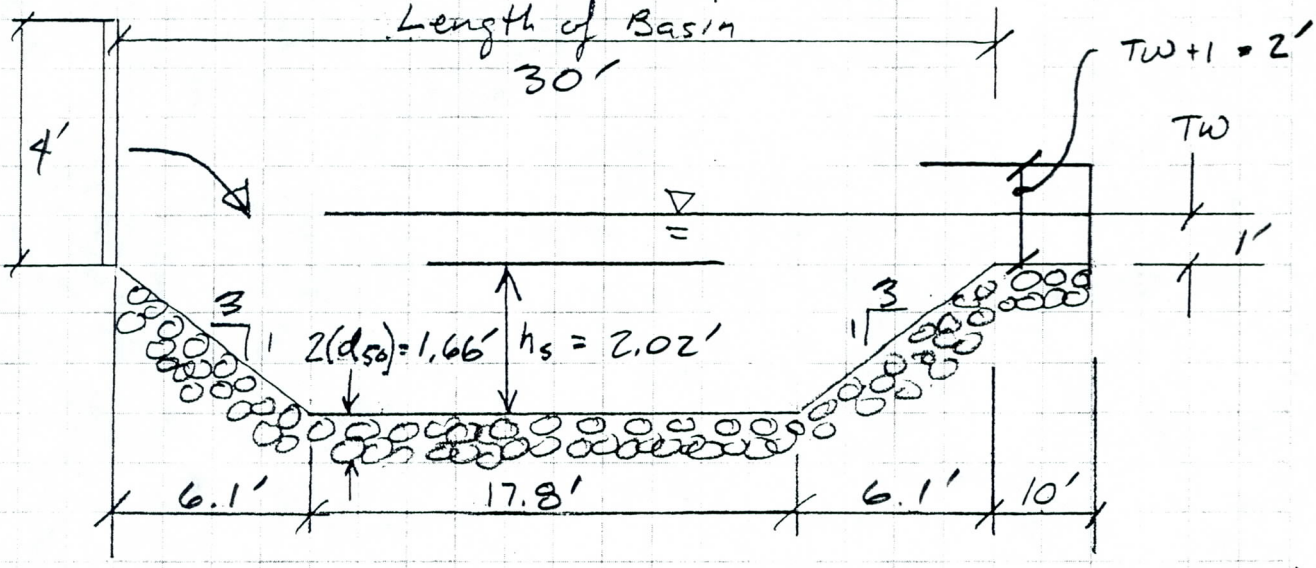
COMPUTATIONS FOR Box Culvert 70 M-2

SHEET NO. 6 OF

DATE 7/26/91

BY BDO CHKD RJT

Riprap Plunge Basin Design (Q100)



Check Rock Size (From Figure XI-2, HEC No. 14)

For $Y_o = 3.36'$ $d_{50} = 10''$ or $0.83'$

$d_{50}/Y_o = \frac{0.83'}{3.36'} = 0.25$, $F = 1.15$

$\frac{h_s}{Y_o} = 0.60$ $h_s = 0.60(3.36') = 2.02'$

Check $\frac{h_s}{d_{50}} = \frac{2.02'}{0.83'} = 2.43' < 4$ and > 2 ∴ OK

Length of Basin

$10\,h_s = 10(2.02') = 20.2'$

or

$3(W_o) = 3(10') = 30'$

$\frac{TW}{Y_o} = \frac{1'}{3.36'} = 0.30 < 0.75$ ∴ OK

Use 30'

Culvert 70 M-2

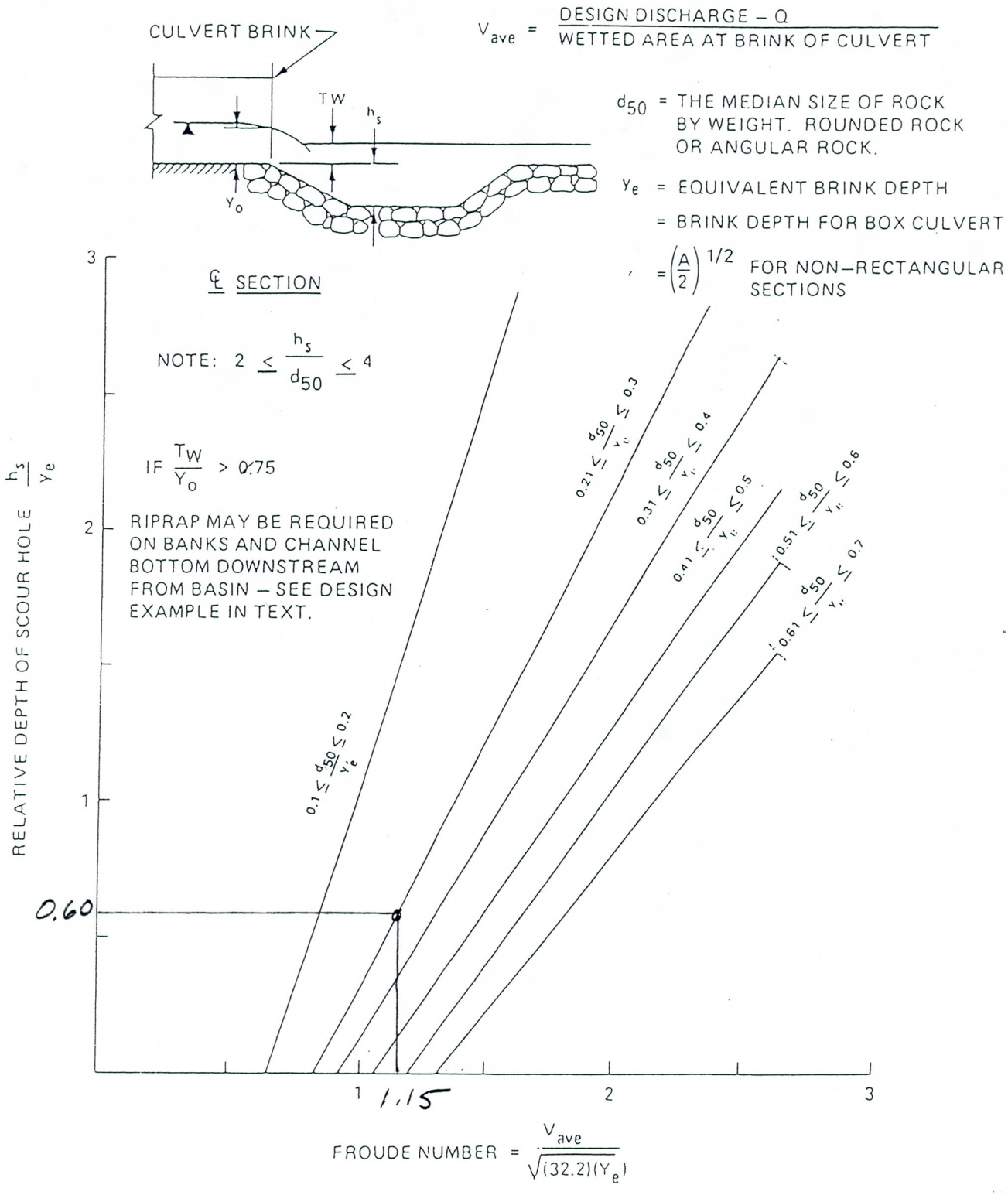


FIGURE X1–2. RELATIVE DEPTH OF SCOUR HOLE VERSUS FROUDE NUMBER AT BRINK OF CULVERT WITH RELATIVE SIZE OF RIPRAP AS A THIRD VARIABLE

SVERDRUP

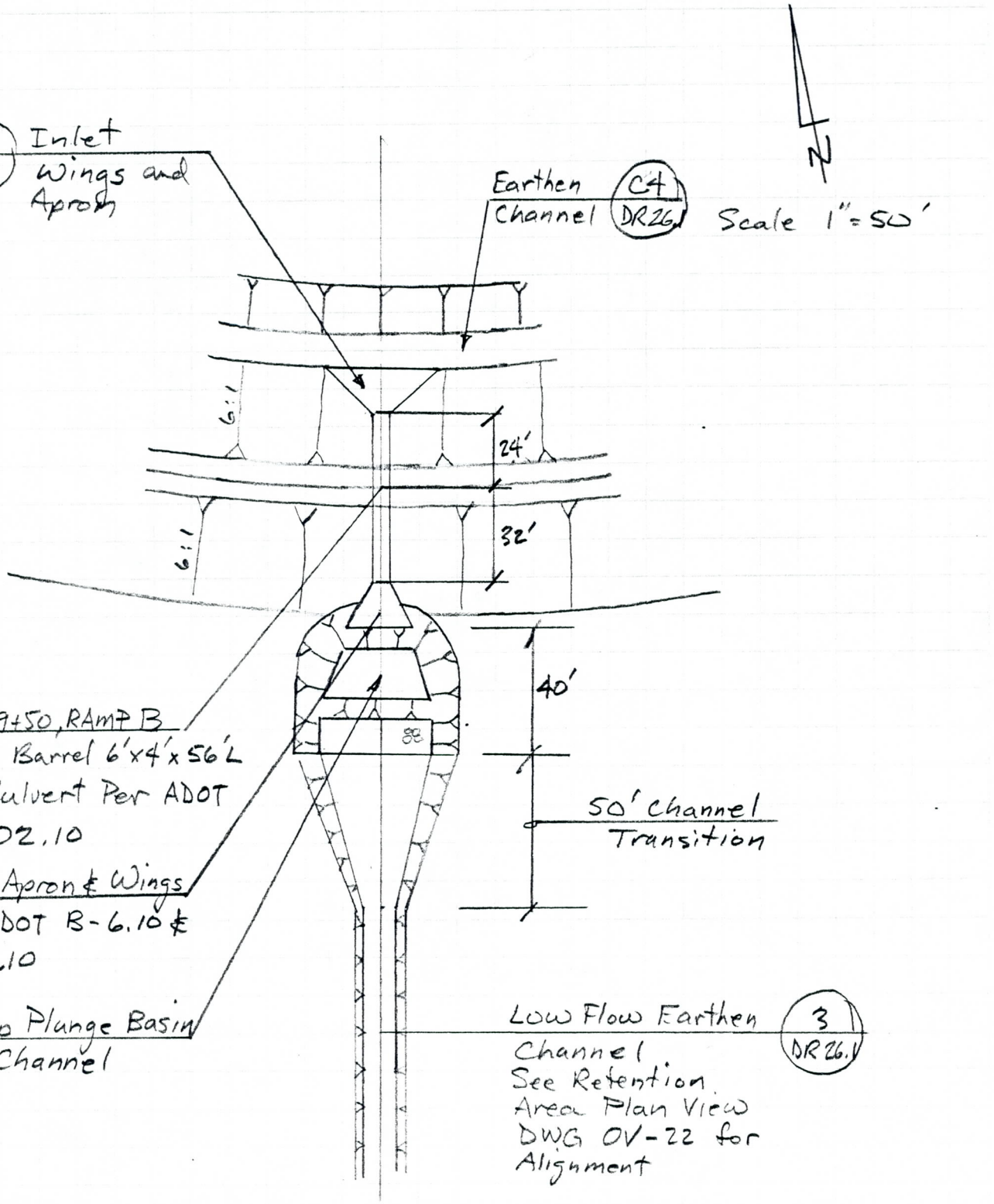
JOB 40477 Toyota

COMPUTATIONS FOR Culvert 70 M-2 [33]
Plan View

SHEET NO. 8 OF

DATE 7/26/91

BY BDO CHKD RJT



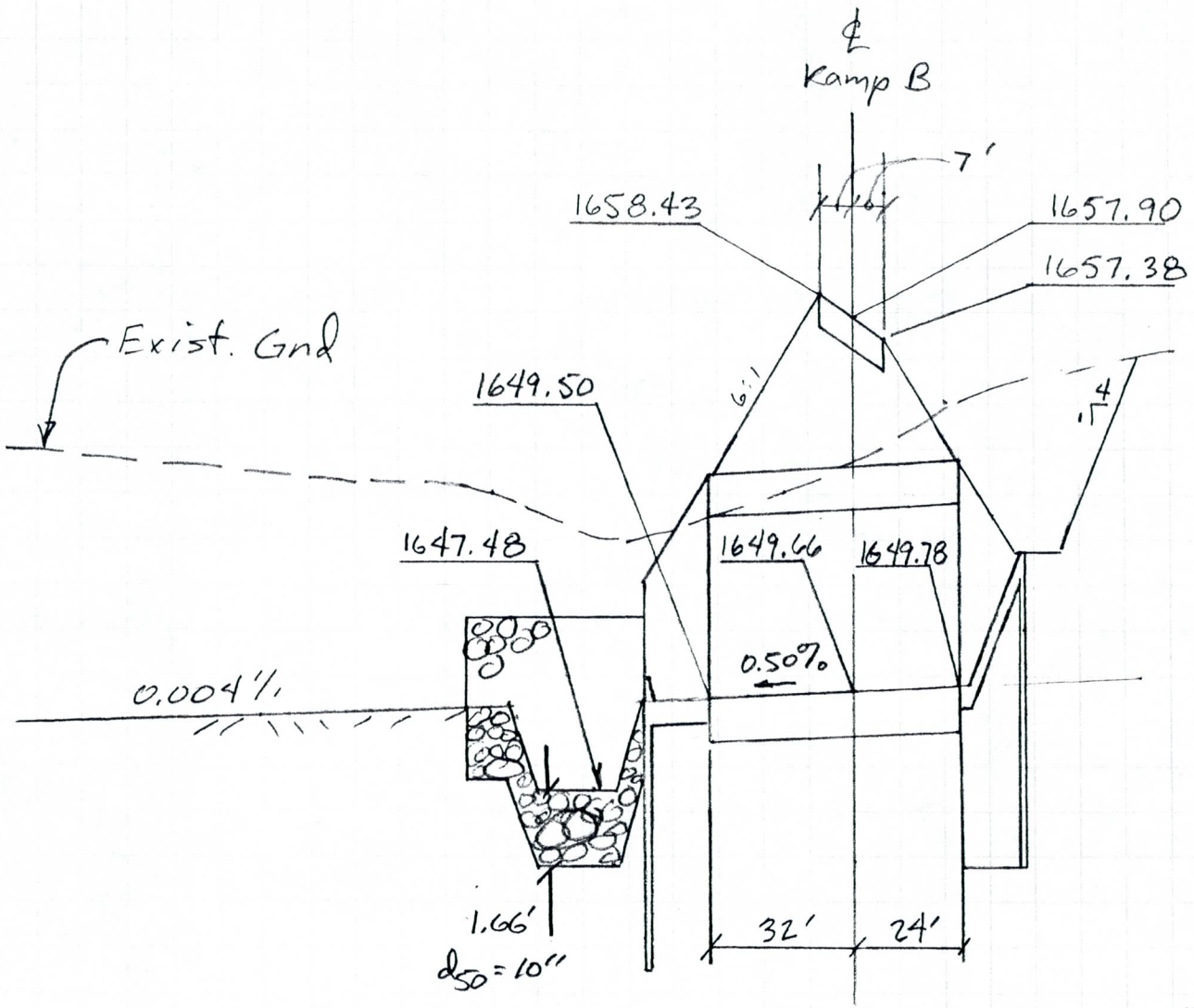
33 BOX CULVERT PLAN VIEW
Sta 19+50 Ramp B
(See Dwg DR-14 For Profile)

SVERDRUP

JOB 40477 Toyota SHEET NO. 9 OF

COMPUTATIONS FOR Culvert 70 M-2 33 DATE 7/25-/91

BY BDO CHKD RVT



Sta 19+50
Ramp B

Skew = 0°
Q100 = 240 cfs

33 Pipe Culvert
Sta 19+50, Ramp B

Scale
Horiz 1" = 40'
Vert 1" = 4'

SVERDRUP

JOB 404 Toyota

COMPUTATIONS FOR Culvert 76-J (34)

SHEET NO 1 OF

DATE 4/17/91

BY BDO CHKD KJT

CULVERT COMPUTATION SHEET

PROJECT:

STATION: 489+60, Oval Track

DESIGNER:

DATE:

HYDROLOGIC AND CHANNEL INFORMATION

DRAINAGE AREA 0.59 sq. miles

Q_1 = 605 cfs

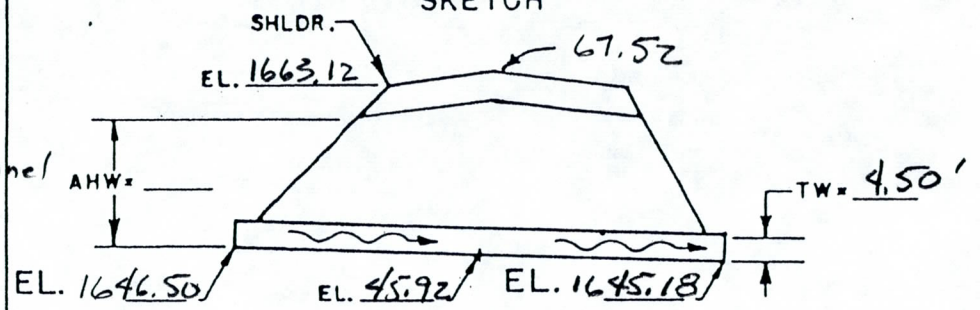
Q_2 =

TW_1 = 4.50 Exist. Channel

TW_2 =

(Q_1 = DESIGN DISCHARGE, SAY Q_{25})
(Q_2 = CHECK DISCHARGE, SAY Q_{50})

SKETCH



S_0 = .0050'/' L = 264' L/100 S_0 =

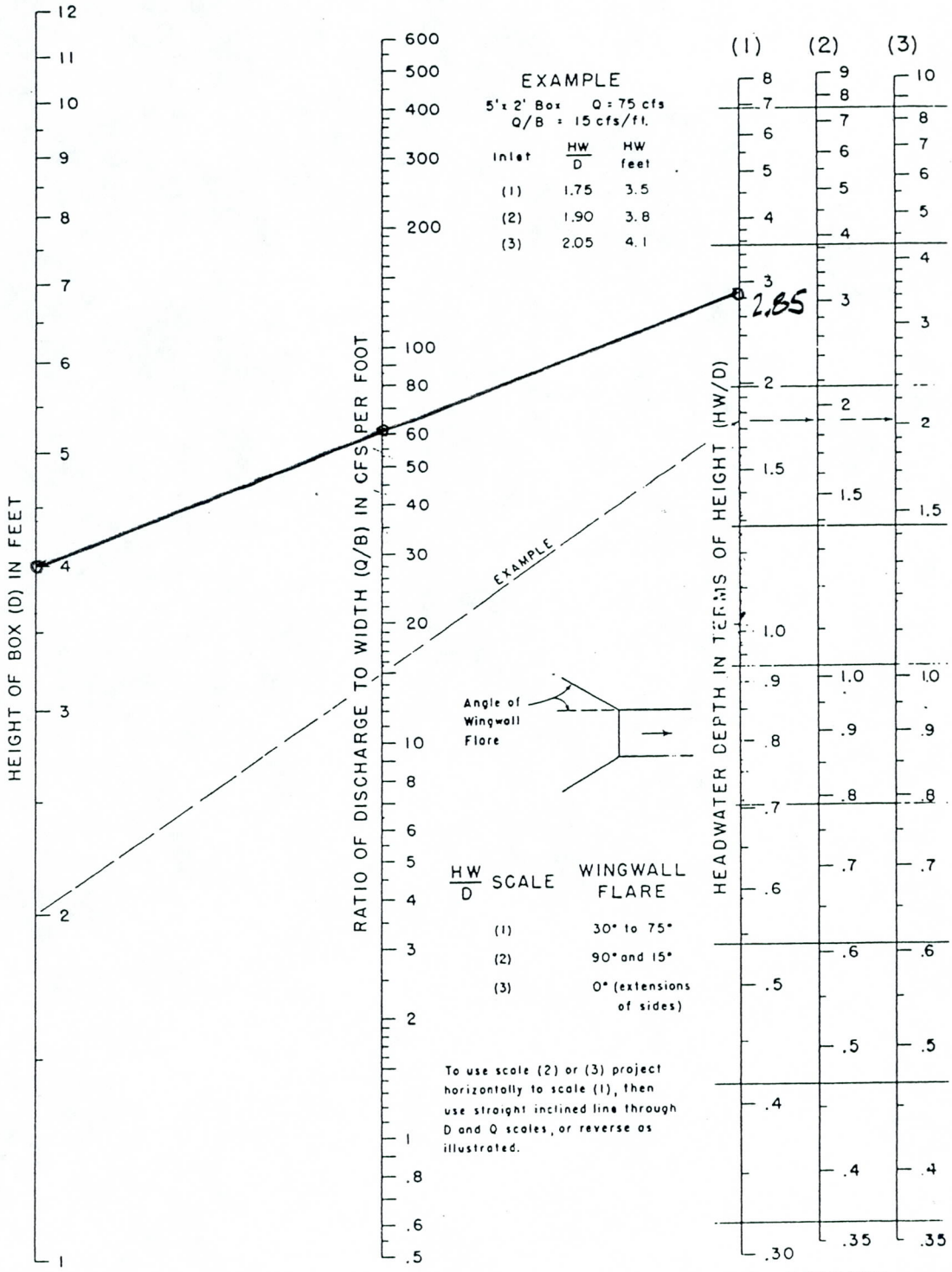
MEAN STREAM VELOCITY = 8.5 fps

CULVERT DESCRIPTION		Q	CAP. CHART HW	HEADWATER COMPUTATION										CONTROL HW	OUTLET VELOCITY	COST	DHW ELEV.	COMMENTS
				INLET CONT.		OUTLET CONTROL $HW = H + h_o - LS_o$												
SIZE	ENTR. TYPE			HW/D	HW	K_e	H	d_c	$\frac{d_c + D}{2}$	TW	h_o	LS_o	HW					
(1) Barrel 10'x4'	Headwall	605		2.85	11.4	0.2	6.6	4.0	4.0	4.50	4.50	1.32	9.78	11.4	15.1		1657.90	Inlet Control

SUMMARY & RECOMMENDATIONS Use grouted riprap plunge basin for outlet erosion protection.

Culvert 76 J

CHART 1



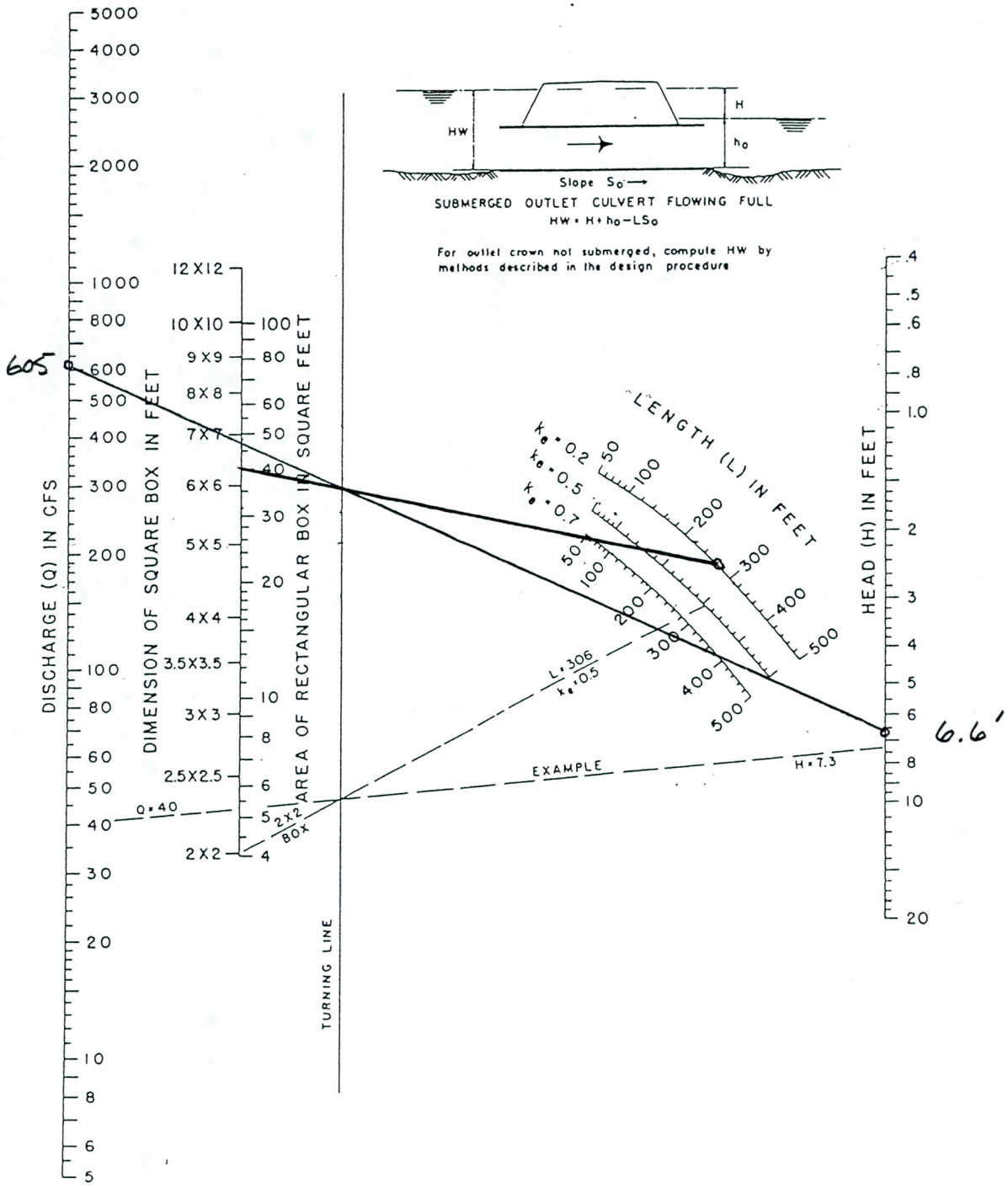
HEADWATER DEPTH FOR BOX CULVERTS WITH INLET CONTROL

BUREAU OF PUBLIC ROADS JAN. 1963

Culvert 76 J

3

CHART 8

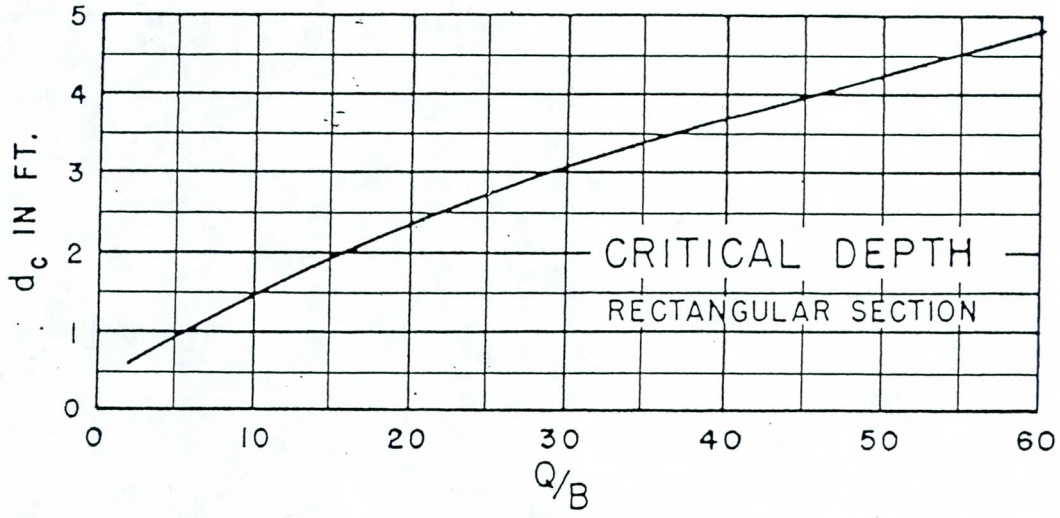


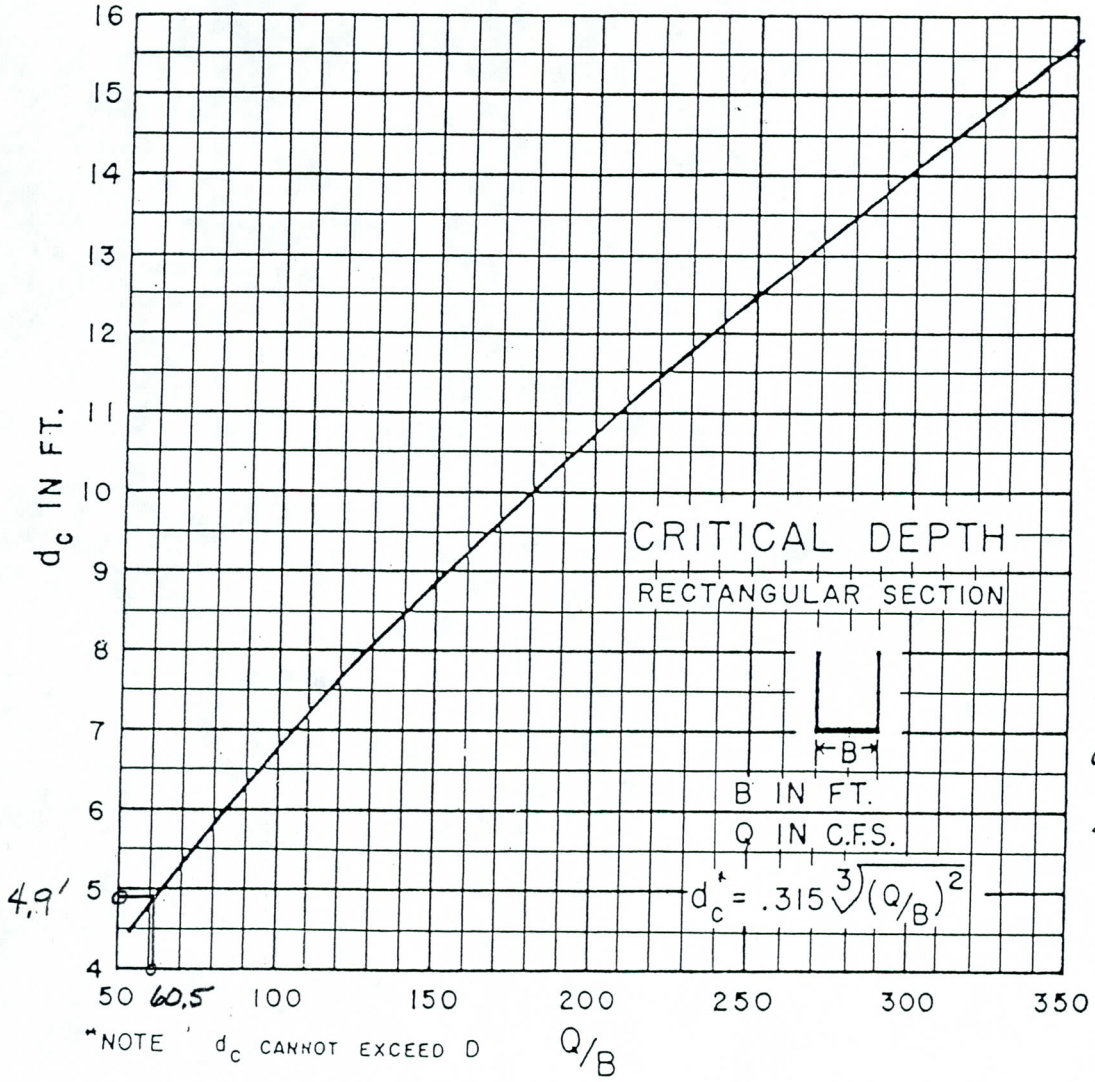
HEAD FOR
CONCRETE BOX CULVERTS
FLOWING FULL
n = 0.012

BUREAU OF PUBLIC ROADS JAN. 1963

Culvert 76 J

CHART 15





Note:
$d_c = 4.90' > 4.0'$
$\therefore$ Use 4.0'

"NOTE d_c CANNOT EXCEED D

BUREAU OF PUBLIC ROADS JAN 1963

SVERDRUP

JOB 40477 Toyota

COMPUTATIONS FOR Culvert 76 J

SHEET NO. 5 OF

DATE 7/17/91

BY BDO CHKD RJT

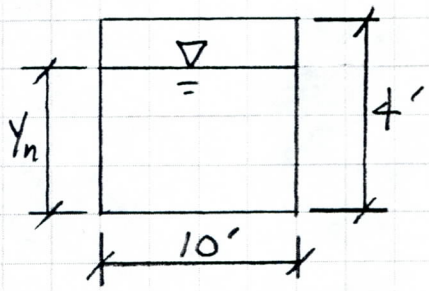
Check depth of flow and velocity using Mannings Equation.

$Q_{100} = 605$ cfs

$n = 0.012$

$S_o = 0.0050$ ft/ft

$Y_n = 4.04' > 4.00'$



Culvert is full use $Q = VA$

$V = Q/A = 605 \text{ cfs} / 40 \text{ ft}^2 = 15.13$ fps

Check Froude Number

$$F = \frac{15.13}{\sqrt{32.2 \times 4}} = 1.33, \text{ Supercritical}$$

$Q_{10} = 421$ cfs

$Y_n = 3.11$ ft, Velocity = 13.53 fps, $F = 1.35$

SVERDRUP

JOB 40477 Toyota

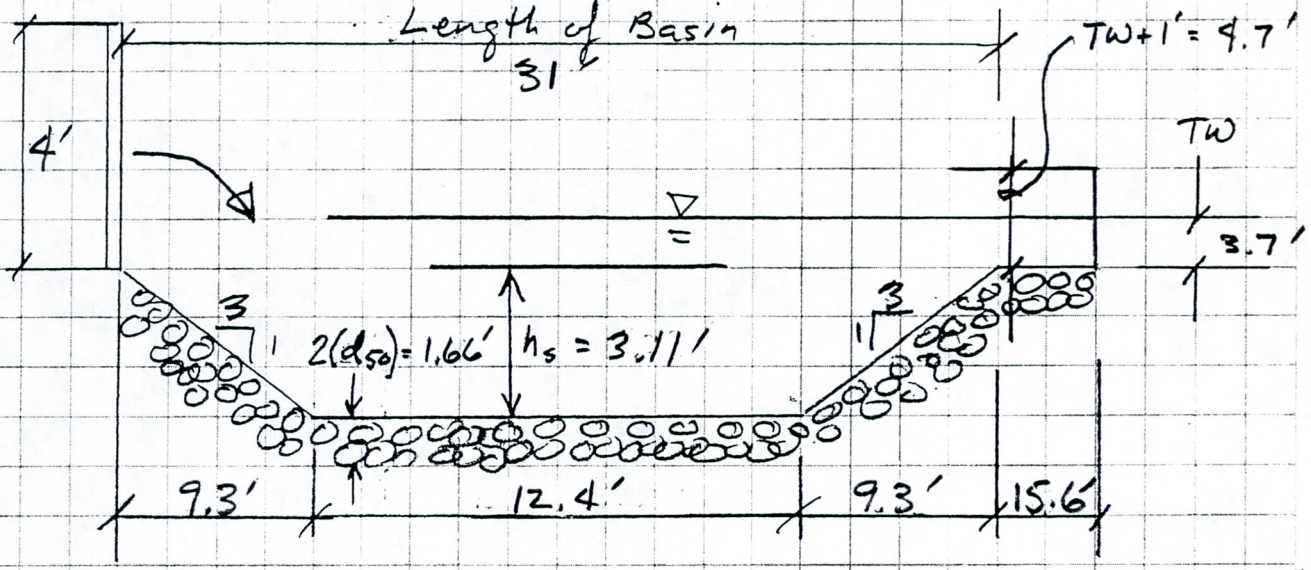
COMPUTATIONS FOR Box Culvert 76 J

SHEET NO. 6 OF

DATE 7/17/91

BY BDO CHKD RJT

Riprap Plunge Basin Design (Q10)



Check Rock Size (From Figure XI-2, HEC No. 14)

For $y_o = 3.11$ ft $\quad d_{50} = 10''$ or 0.83

$$d_{50}/y_o = \frac{.83}{3.11} = 0.27 \;, \quad F = 1.35$$

$$\frac{h_s}{y_o} = 1.0 \qquad h_s = 1.0\,(3.11') = 3.11'$$

Check $\quad \dfrac{h_s}{d_{50}} = \dfrac{3.11}{0.83} = 3.75 < 4 \text{ and } > 2$

Length of Basin

$10\,h_s = 10\,(3.11) = 31.1$

or

$3(W_o) = 3(10) = 30$

Use 31'

Culvert 76 J

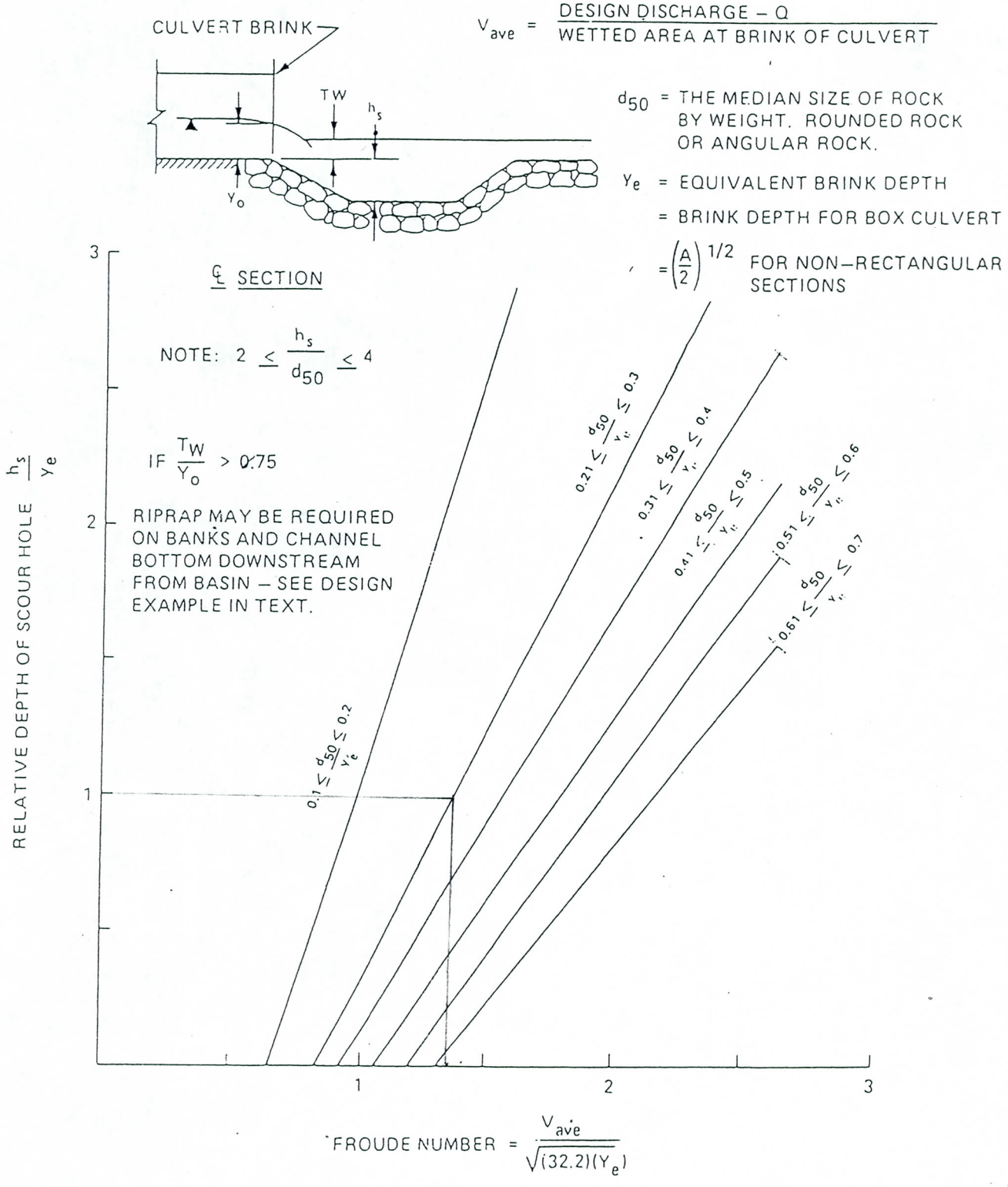


FIGURE X1–2. RELATIVE DEPTH OF SCOUR HOLE VERSUS FROUDE NUMBER AT BRINK OF CULVERT WITH RELATIVE SIZE OF RIPRAP AS A THIRD VARIABLE

SVERDRUP

JOB 40477 Toyota

COMPUTATIONS FOR Box Culvert 76 I

SHEET NO. 8 OF

DATE 7/17/91

BY BDO CHKD RJT

$TW/Y_o = \frac{3.7'}{3.11'} = 1.19 > 0.75$ ∴ Check downstream riprap lining for channel protection.

Utilize figure XI-3 for existing average velocity along channel. Compute equivalent circular diameter D_e for brink area from:

$A = \pi D_e^2/4 = Y_o(W_o) = 3.11(10) = 31.1$

$D_e = (31.1(4)/\pi)^{1/2} = 6.29'$

From downstream cross section Q10 velocity is 7.9 fps. Culvert outlet velocity is 13.5 fps.

L/D_e	L	V_L/V_o	V_L
10	62.9'	.59	8.0 ~ 7.9 fps ∴ OK

∴ Need riprap lining for approximately 65 feet from the end of the culvert outlet apron.

SVERDRUP

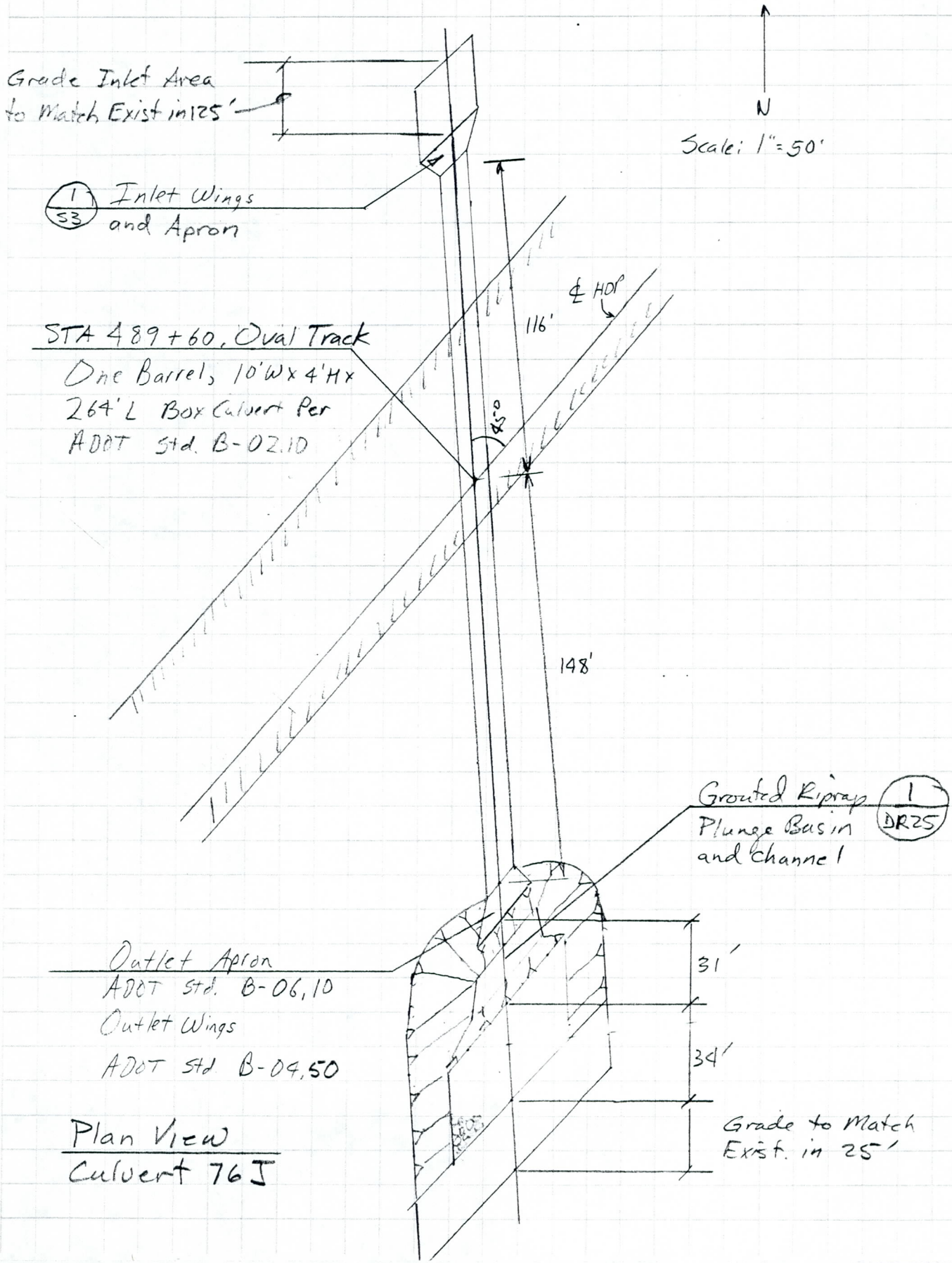
JOB 40477 Toyota

SHEET NO. 9 OF

DATE 7-16-91

COMPUTATIONS FOR Culvert 76 J Plan View
MST Sta. 489+60 (34)

BY DFP CHKD RJT



Plan View
Culvert 76 J

SVERDRUP

JOB 40422 Toyota

COMPUTATIONS FOR Culvert 76-J 34

HST Sta. 489+60 34

SHEET NO. ____ OF ____

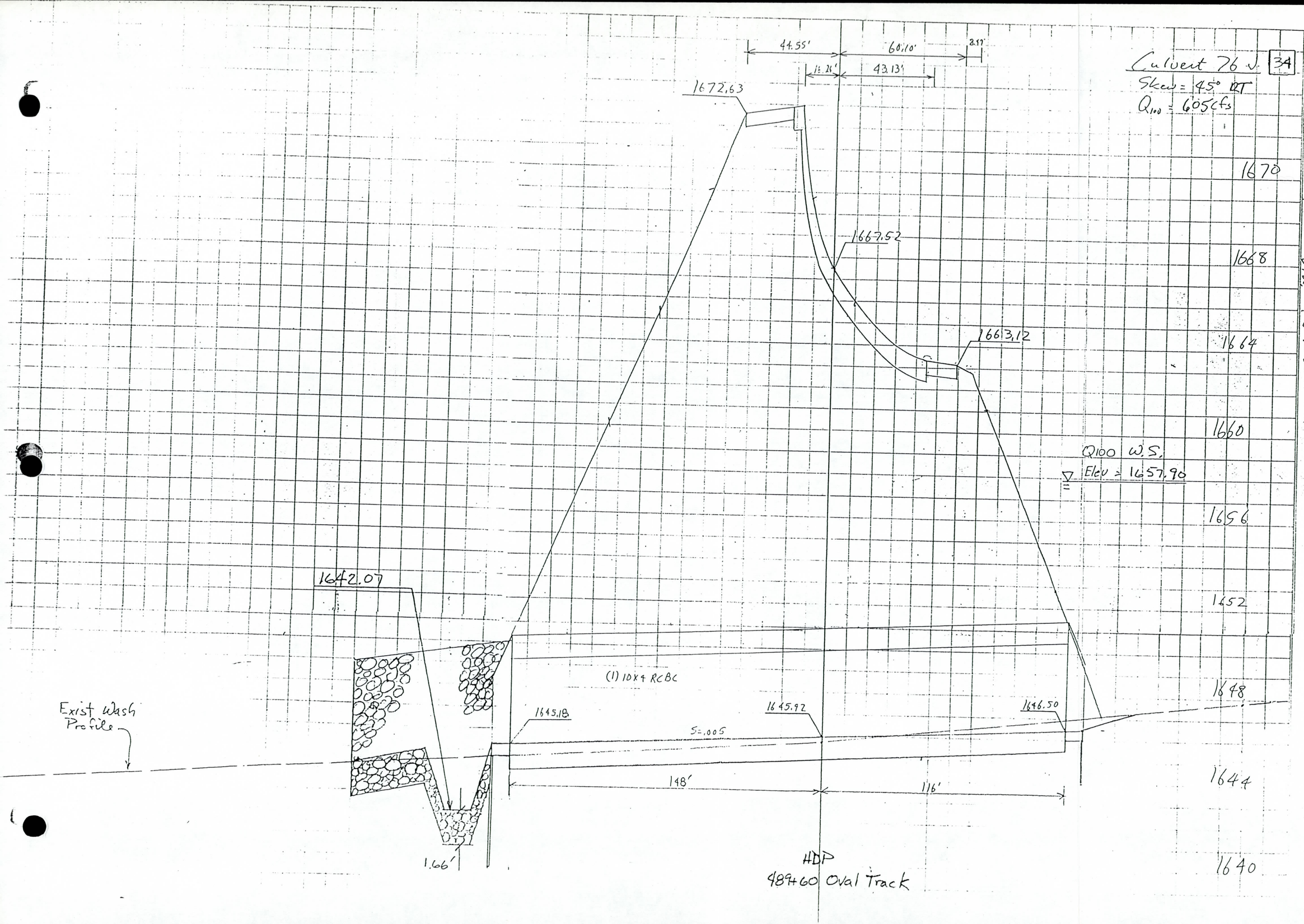
DATE 7-13-91

BY DEP CHKD RVT

Culvert 76 J 34

Skew = 45° RT

Q_{100} = 605 cfs



SECTION NUMBER TW76J 7/17/91

Channel Slope: 0.0069 ft./ft.

CROSS SECTION DATA:

OFFSET	10	49.9	64.3	77.9	79.2	82	82.9	91.1	101.3	114.6	127.1	161.4	170	178.3	185.1
ELEV.	54.5	53.11	52.58	49.69	49.31	49.19	49.59	51.82	52.59	50.65	52.75	50.75	44.41	44.48	47.72
N	N/A	0.035	0.035	0.035	0.025	0.025	0.025	0.035	0.035	0.035	0.035	0.035	0.4	0.025	0.04

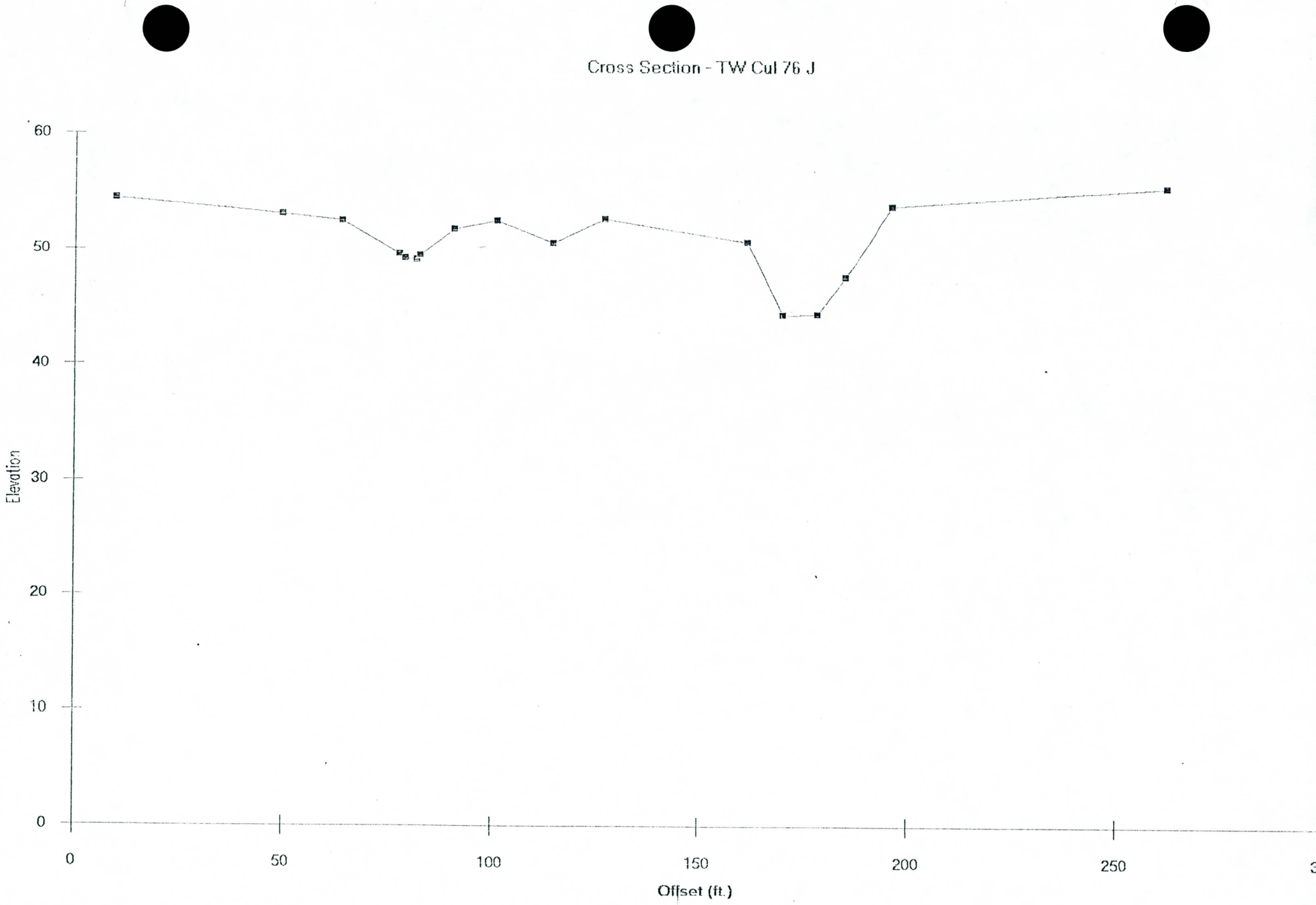
STAGE-DISCHARGE DATA:

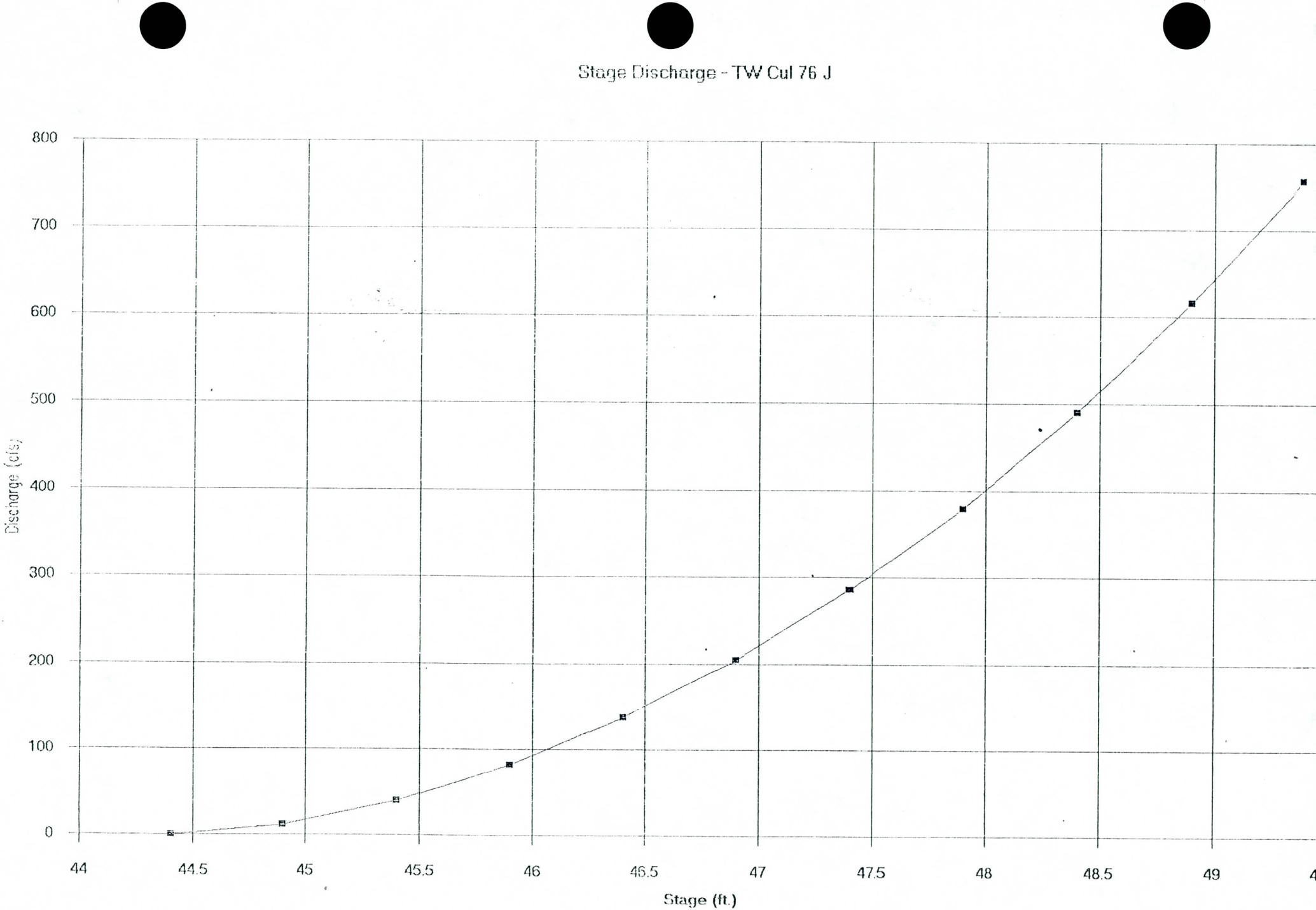
STAGE:	44.4														
WET PER.		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
AREA		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYD.RAD.		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Q		0	0	0	0	0	0	0	0	0	0	0	0	0	0
STAGE:	44.9														
WET PER.		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8	8.3	1.0
AREA		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	3.8	0.2
HYD.RAD.		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.5	0.2
Q		0	0	0	0	0	0	0	0	0	0	0	0	11	0
STAGE:	45.4														
WET PER.		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.7	8.3	2.1
AREA		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7	7.9	0.9
HYD.RAD.		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	1.0	0.4
Q		0	0	0	0	0	0	0	0	0	0	0	0	38	2
STAGE:	45.9														
WET PER.		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.5	8.3	3.3
AREA		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.5	12.1	2.1
HYD.RAD.		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	1.5	0.6
Q		0	0	0	0	0	0	0	0	0	0	0	0	77	5
STAGE:	46.4														
WET PER.		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.4	8.3	4.5
AREA		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.7	16.2	3.9
HYD.RAD.		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8	2.0	0.9
Q		0	0	0	0	0	0	0	0	0	0	0	1	125	11
STAGE:	46.9														
WET PER.		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.2	8.3	5.6
AREA		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.2	20.4	6.1
HYD.RAD.		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	2.5	1.1
Q		0	0	0	0	0	0	0	0	0	0	0	1	183	20

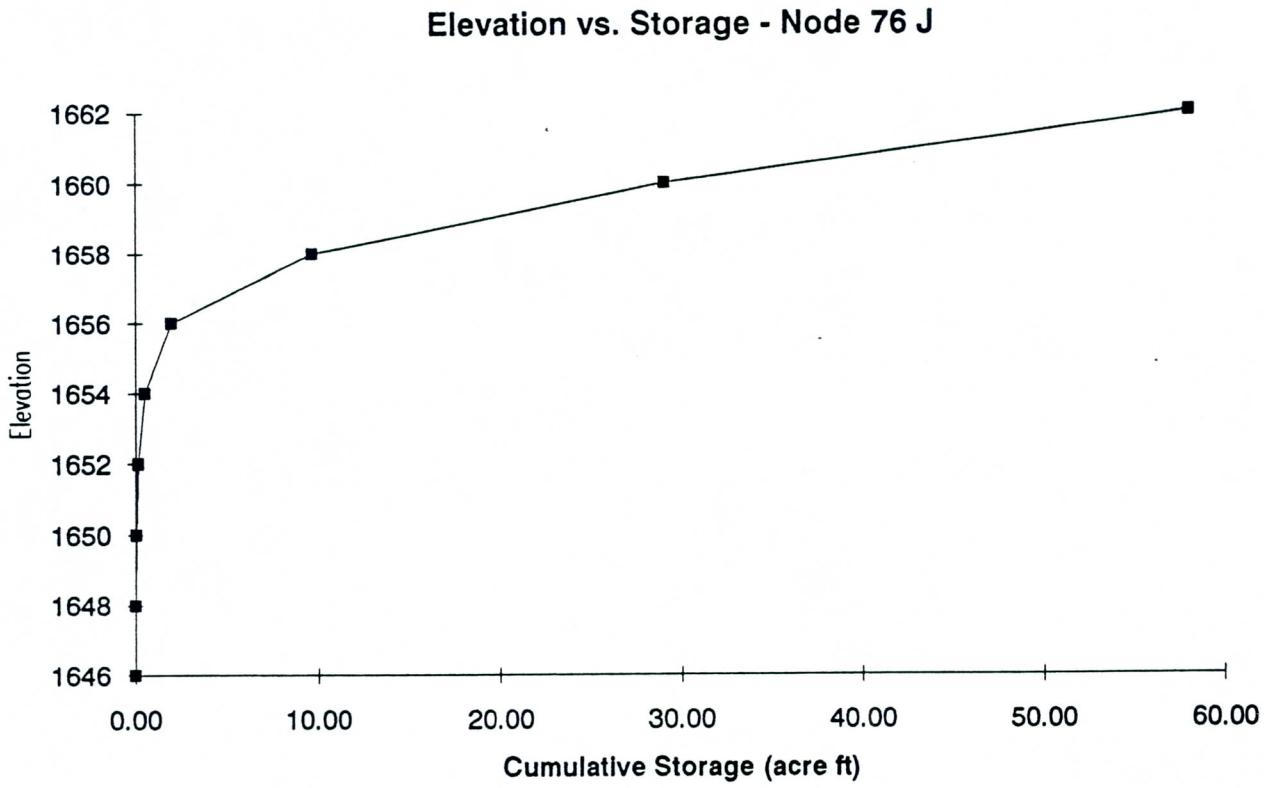
SECTION NUMBER TW76J 7/17/91

STAGE:	47.4													
WET PER.		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.0	8.3	6.8
AREA		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.1	24.5	8.9
HYD.RAD.		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.2	3.0	1.3
Q		0	0	0	0	0	0	0	0	0	0	0	2	250	33
STAGE:	47.9														
WET PER.		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.9	8.3	7.5
AREA		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.3	28.7	12.2
HYD.RAD.		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.4	3.5	1.6
Q		0	0	0	0	0	0	0	0	0	0	0	3	324	52
STAGE:	48.4														
WET PER.		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.7	8.3	7.5
AREA		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.8	32.8	15.6
HYD.RAD.		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.6	4.0	2.1
Q		0	0	0	0	0	0	0	0	0	0	0	5	406	79
STAGE:	48.9														
WET PER.		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.6	8.3	7.5
AREA		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	13.7	37.0	19.0
HYD.RAD.		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.8	4.5	2.5
Q		0	0	0	0	0	0	0	0	0	0	0	6	495	109
STAGE:	49.4														
WET PER.		0.0	0.0	0.0	0.3	3.1	3.6	0.0	0.0	0.0	0.0	0.0	8.4	8.3	7.5
AREA		0.0	0.0	0.0	0.0	0.4	0.5	0.0	0.0	0.0	0.0	0.0	16.9	41.1	22.4
HYD.RAD.		0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0	2.0	5.0	3.0
Q		0	0	0	0	0	1	0	0	0	0	0	8	591	143

W.S. Elev.	44.4	44.9	45.4	45.9	46.4	46.9	47.4	47.9	48.4	48.9	49.4
Q	0	11	40	82	137	205	285	379	490	616	757
A	0.0	4.1	9.5	15.7	22.8	30.7	39.5	49.2	60.1	72.2	86.0
V	0.0	2.7	4.2	5.2	6.0	6.7	7.2	7.7	8.2	8.5	8.8


Cross Section - TW Cul 76 J
60
50
40
30
20
10
0
Elevation
0
50
100
150
200
250
Offset (ft.)


Stage Discharge - TW Cul 76 J
800
700
600
500
400
300
200
100
0
Discharge (cfs)
44
44.5
45
45.5
46
46.5
47
47.5
48
48.5
49
Stage (ft.)


Elevation vs. Storage - Node 76 J
1662
1660
1658
1656
1654
1652
1650
1648
1646
Elevation
0.00
10.00
20.00
30.00
40.00
50.00
60.00
Cumulative Storage (acre ft)

SVERD[illegible] IP

JOB 404[illegible] Toyota SHEET NO 1 OF

DATE 6/3/91

COMPUTATIONS FOR Proposed Culvert 70A [35] BY BDO CHKD KJT

CULVERT COMPUTATION SHEET

PROJECT: _____ DESIGNER: _____

STATION: 46+75 DATE: _____

HYDROLOGIC AND CHANNEL INFORMATION

DRAINAGE AREA _____

Q_1 = 1582 cfs TW_1 = 4.0'

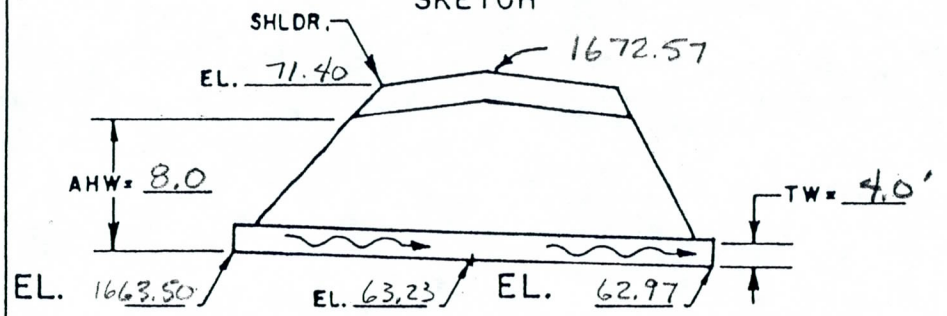
Q_2 = _____ TW_2 = _____

Peak Outlet Discharge

(Q_1 = DESIGN DISCHARGE, SAY Q_{25}) Q100

(Q_2 = CHECK DISCHARGE, SAY Q_{50})

SKETCH



S_0 = .0050'/' L = 106' L/100 S_0 = _____

MEAN STREAM VELOCITY = 4.4 ft/s

CULVERT DESCRIPTION SIZE	CULVERT DESCRIPTION ENTR. TYPE	Q	CAP. CHART HW	HEADWATER COMPUTATION: INLET CONT. HW/D	INLET CONT. HW	OUTLET CONTROL HW = H + h_o − LS_o: K_e	H	d_c	$\frac{d_c + D}{2}$	TW	h_o	LS_o	HW	CONTROL HW	OUTLET VELOCITY	COST	DHW ELEV.	COMMENTS
(3)Bar. 10x5	Headwalls 20°Skew	1582/3 527		1.53	7.65	0.20	2.40	4.42	4.71	4.00	4.71	0.53	6.58	7.65	14.4		1671.15	Inlet Control

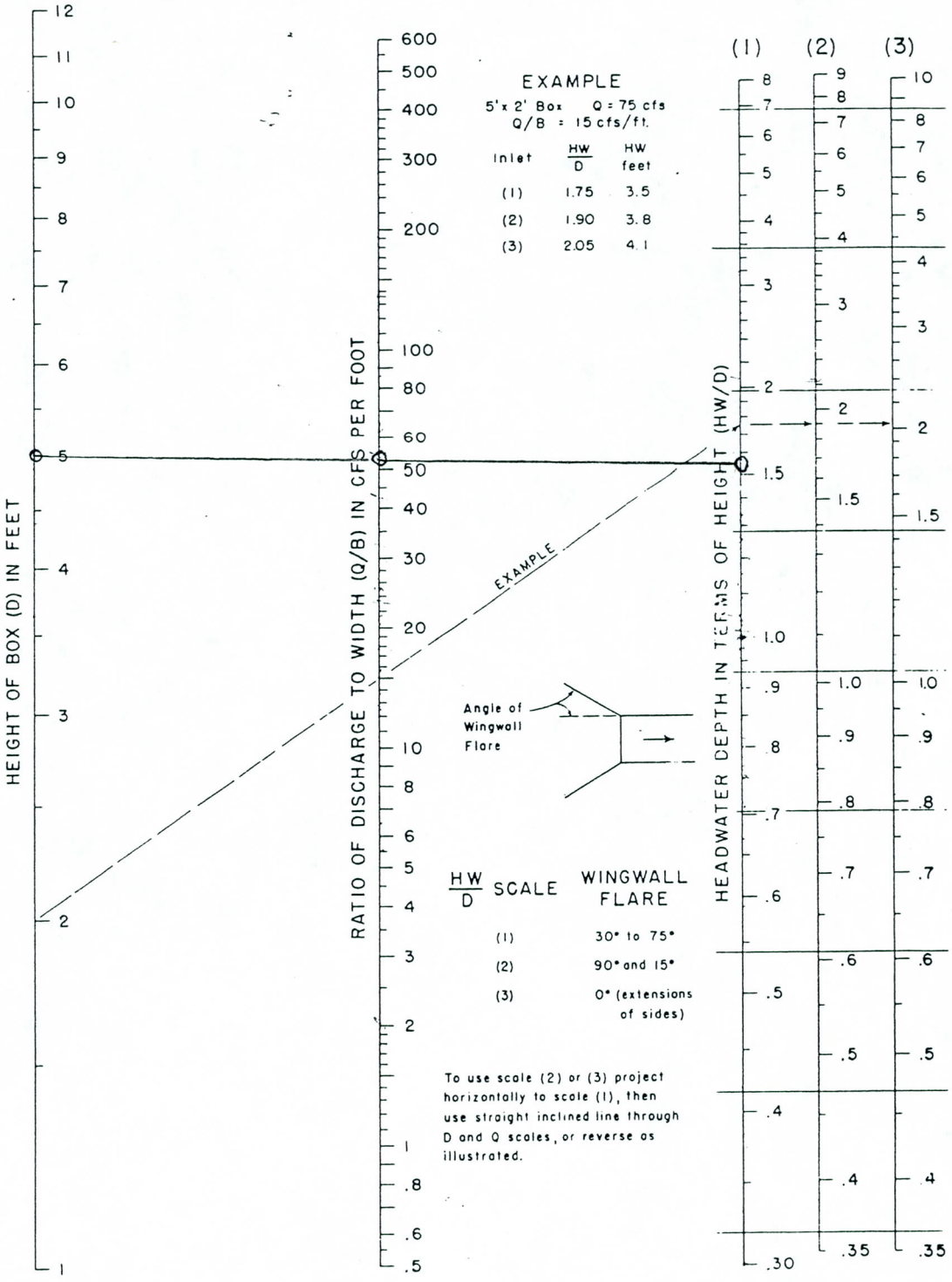
SUMMARY & RECOMMENDATIONS

Use riprap plunge basin for erosion control. Design for Q10.

B-1

Culvert 70 A

CHART 1

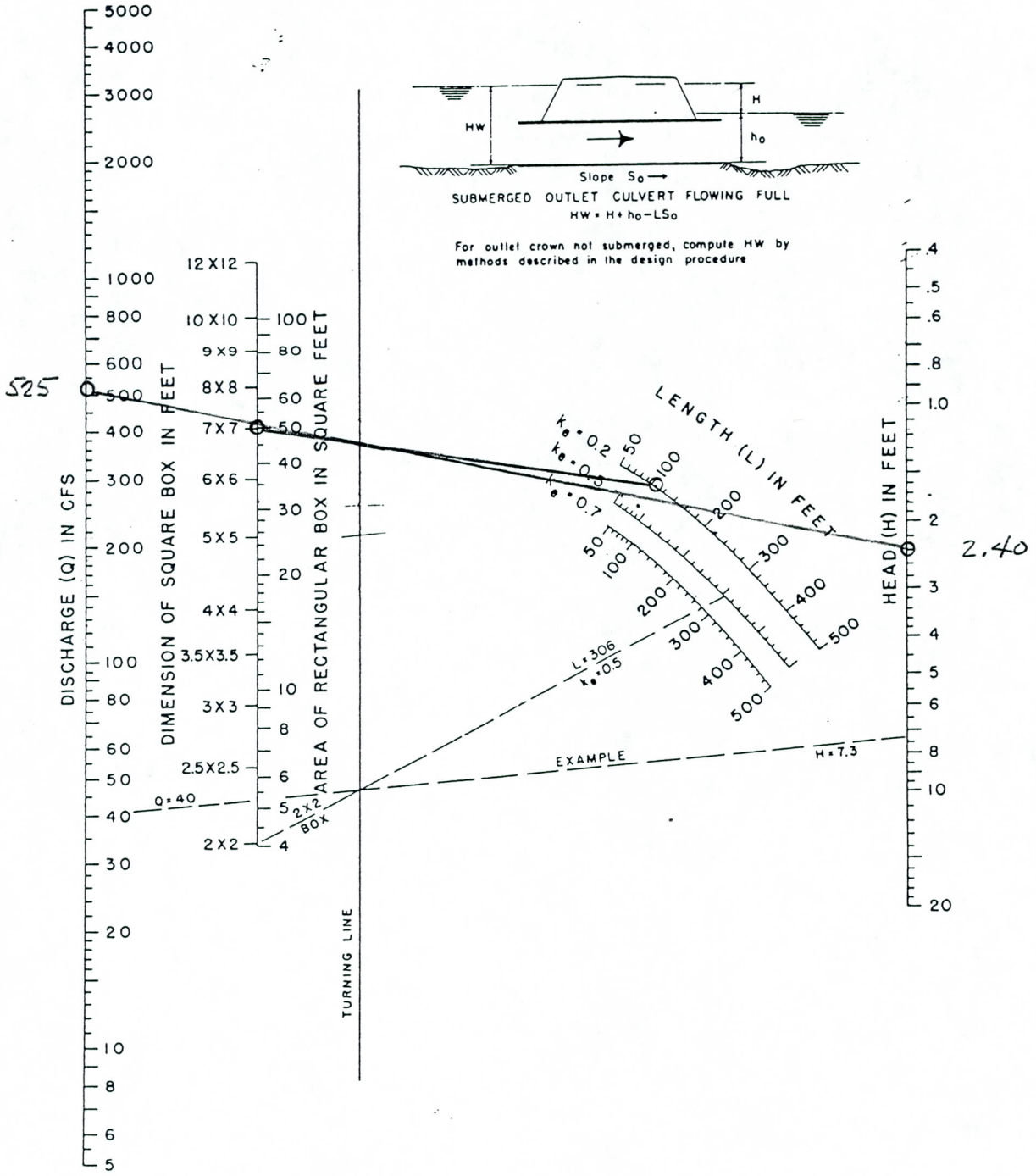


HEADWATER DEPTH FOR BOX CULVERTS WITH INLET CONTROL

BUREAU OF PUBLIC ROADS JAN. 1953

Culvert 70A

CHART 8

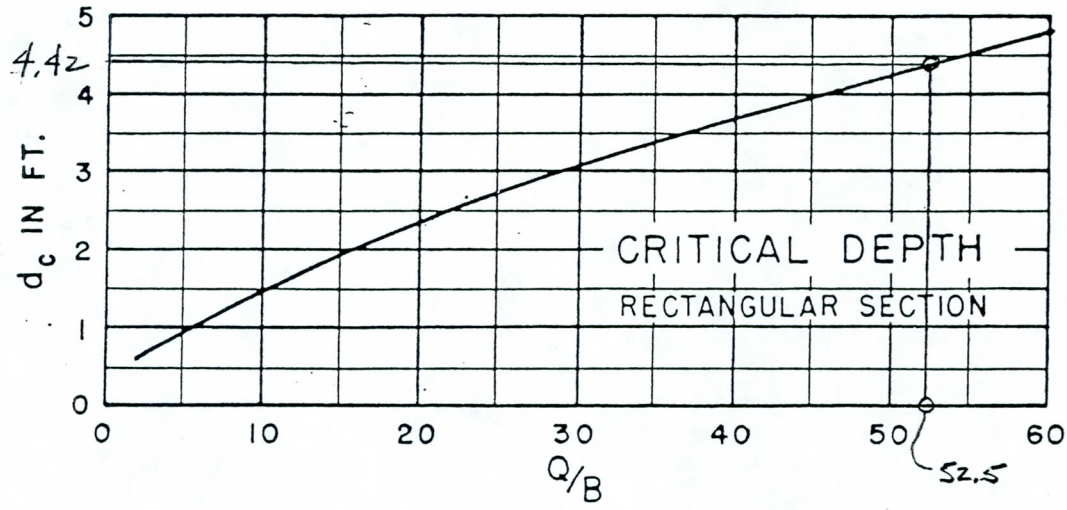


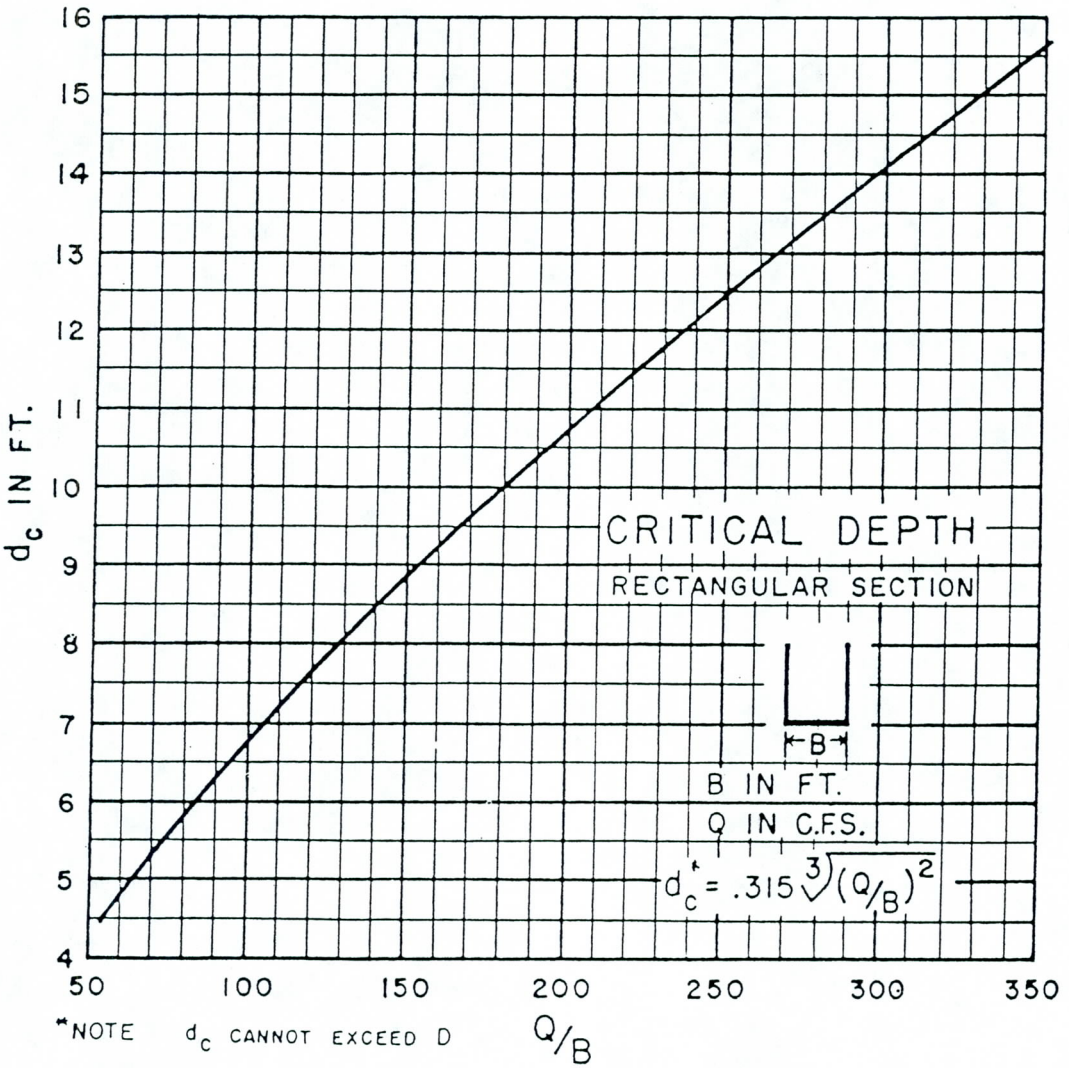
HEAD FOR
CONCRETE BOX CULVERTS
FLOWING FULL
n = 0.012

BUREAU OF PUBLIC ROADS JAN. 1963

Calvert 70 A

CHART 15





*NOTE d_c CANNOT EXCEED D

BUREAU OF PUBLIC ROADS JAN 1963

SVERDRUP

JOB 40477 Toyota

COMPUTATIONS FOR Box Culvert 70A

SHEET NO. 5 OF

DATE 6/3/91

BY BDO CHKD RJT

Check depth of Flow using Manning Equation

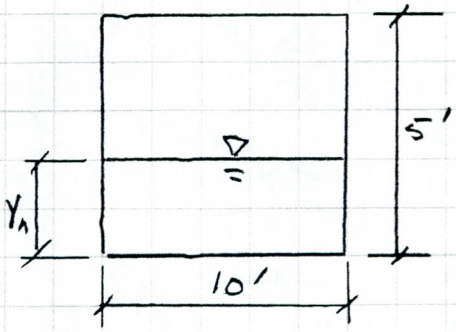
$Q_{100} = 1582$ cfs

$Q_{100/3\,Bar} = 527$ cfs/cell

$n = 0.012$

$S_o = 0.0050$ ft/ft

$Y_n \sim 3.65'$



$A = 3.65 \times 10 = 36.5'$

$WP = 3.65(2) + 10 = 17.30'$

$R_h = A/WP = 36.5/17.30 = 2.1098'$

$$V = \frac{1.49}{.012}(2.1098)^{.666}(.005)^{1/2} = 14.44 \text{ fps}$$

$Q = VA = 14.44\,(36.50) = 527$ cfs (OK)

Check Froude Number

$$F = \frac{V}{\sqrt{g Y_c}} = \frac{14.44}{\sqrt{32.2(3.65)}} = 1.33$$ Supercritical

Channel needs protection, Use Grouted Riprap Plunge Basin $F < 3.0$ OK.

For $Q_{10} = 430$ cfs 143 cfs/barrel

$Y_n = 1.49'$ $V = 9.61$ fps $F = 1.39$

SVERDRUP

JOB 40477 Toyota

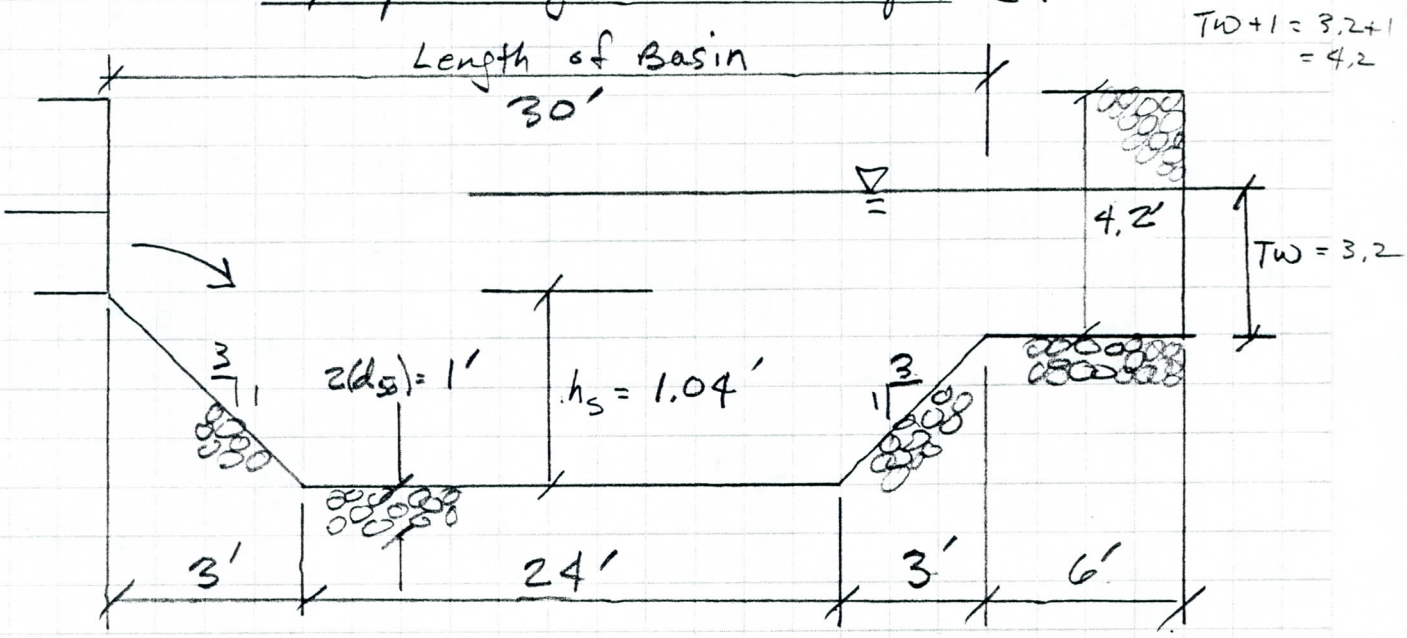
COMPUTATIONS FOR Box Culvert 70A

SHEET NO. 6 OF

DATE 6/8/91

BY BDO CHKD RJT

Riprap Plunge Basin Design (Q10)



Check Rock Size (From Figure X1-2, HEC No 14)

For $Y_o = 1.49'$ $d_{50} = 6''$ or $0.50'$

$$d_{50}/Y_o = \frac{0.50}{1.49} = 0.34, \quad \# = 1.39$$

$$\frac{h_s}{Y_o} = 0.7 \qquad h_s = 0.7(1.49) = 1.04'$$

Check $\frac{h_s}{d_{50}} = \frac{1.04'}{0.50} = 2.08 > 2$ but < 4 OK

Length of Basin

$$10\ h_s = 10(1.04) = 10.4'$$

or

$$3(w_o) = 3(10) = 30' \qquad \text{Use } 30'$$

Culvert 70A

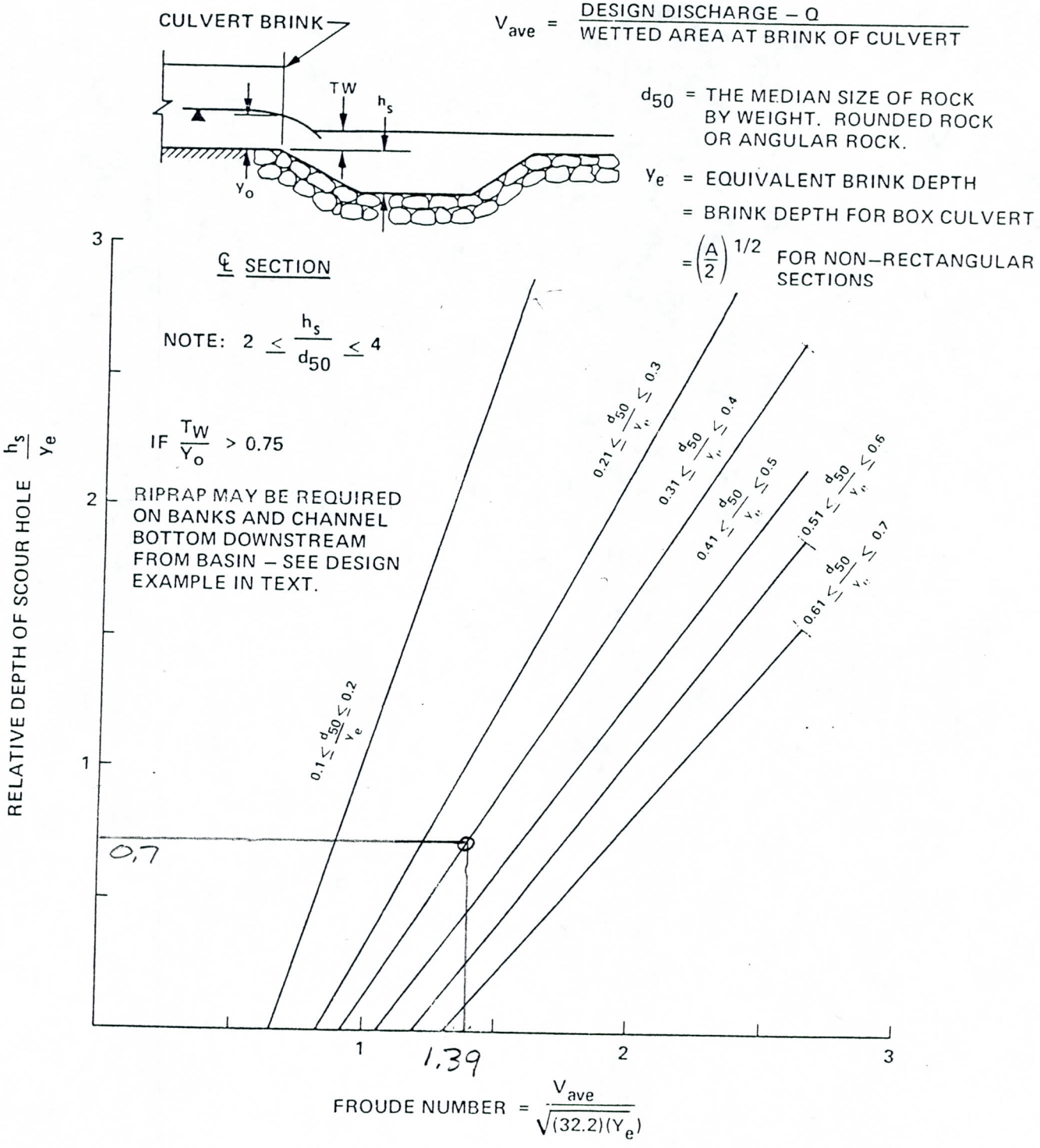


FIGURE X1–2. RELATIVE DEPTH OF SCOUR HOLE VERSUS FROUDE NUMBER AT BRINK OF CULVERT WITH RELATIVE SIZE OF RIPRAP AS A THIRD VARIABLE

SVERDRUP

JOB 40477 Toyota SHEET NO. 8 OF

COMPUTATIONS FOR Box Culvert DATE 6/19/91

BY BDO CHKD RJT

$TW/Y_o = \frac{3.2}{1.49} = 2.15 > 0.75$ ∴ Check downstream riprap lining for channel protection.

Utilize figure XI-3 for existing average velocity along channel. Compute equivalent circular diameter. D_e for brink area from:

$A = \pi D_e^2/4 = Y_o(W_o) = 1.49(10) = 14.9\ ft^2$

$D_e = (14.9(4)/\pi)^{1/2} = 4.36'$

From downstream cross section Q10 velocity is 3.4 fps. Culvert outlet velocity is 9.6 fps.

L/D_e	L	V_L/V_o	V_L
10	43.6	.59	5.66
15	65.4	.36	3.46 ~ 3.4 fps OK

∴ Need riprap lining for approximately 65 feet from the end of the culvert outlet apron.

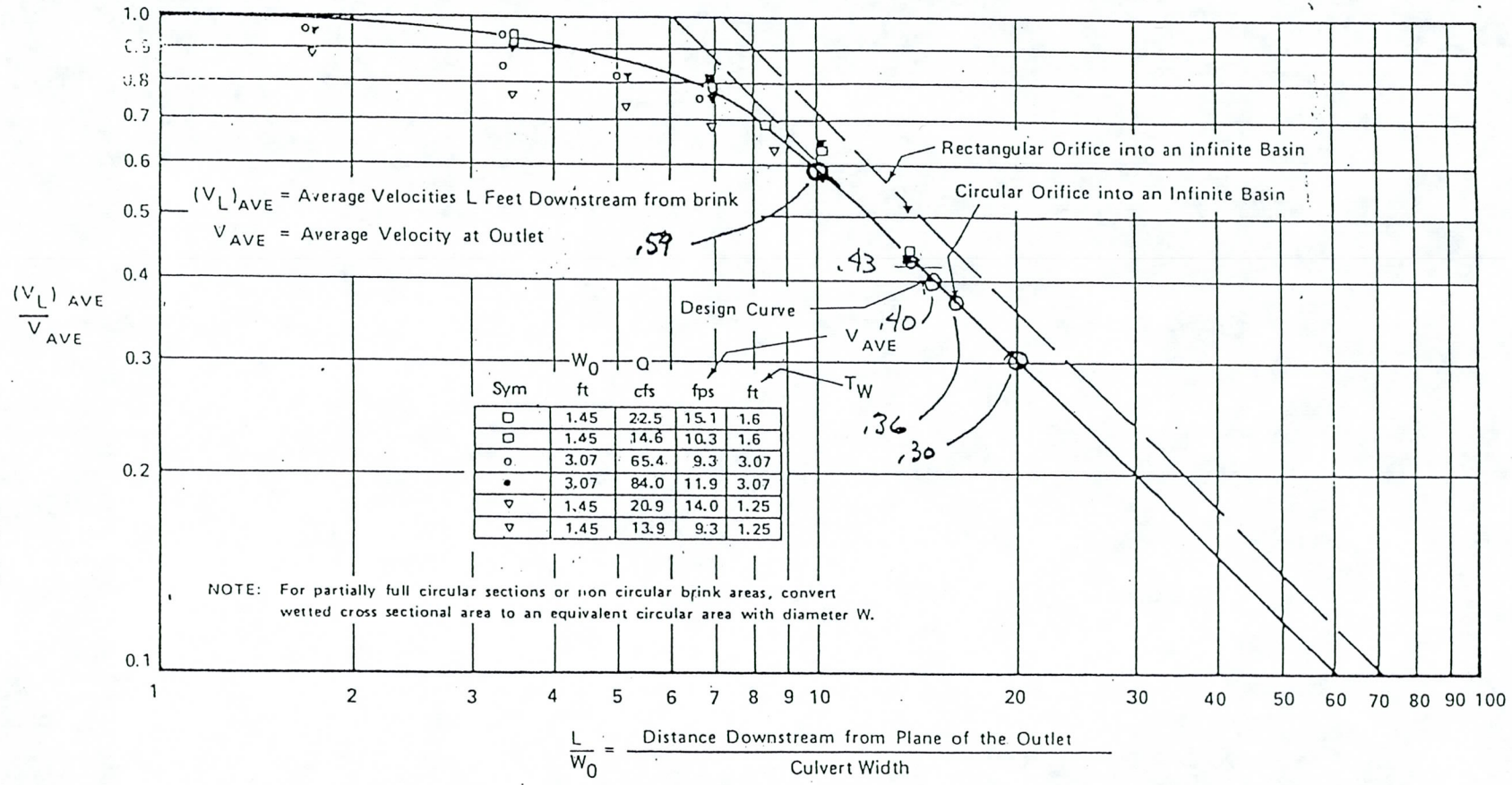


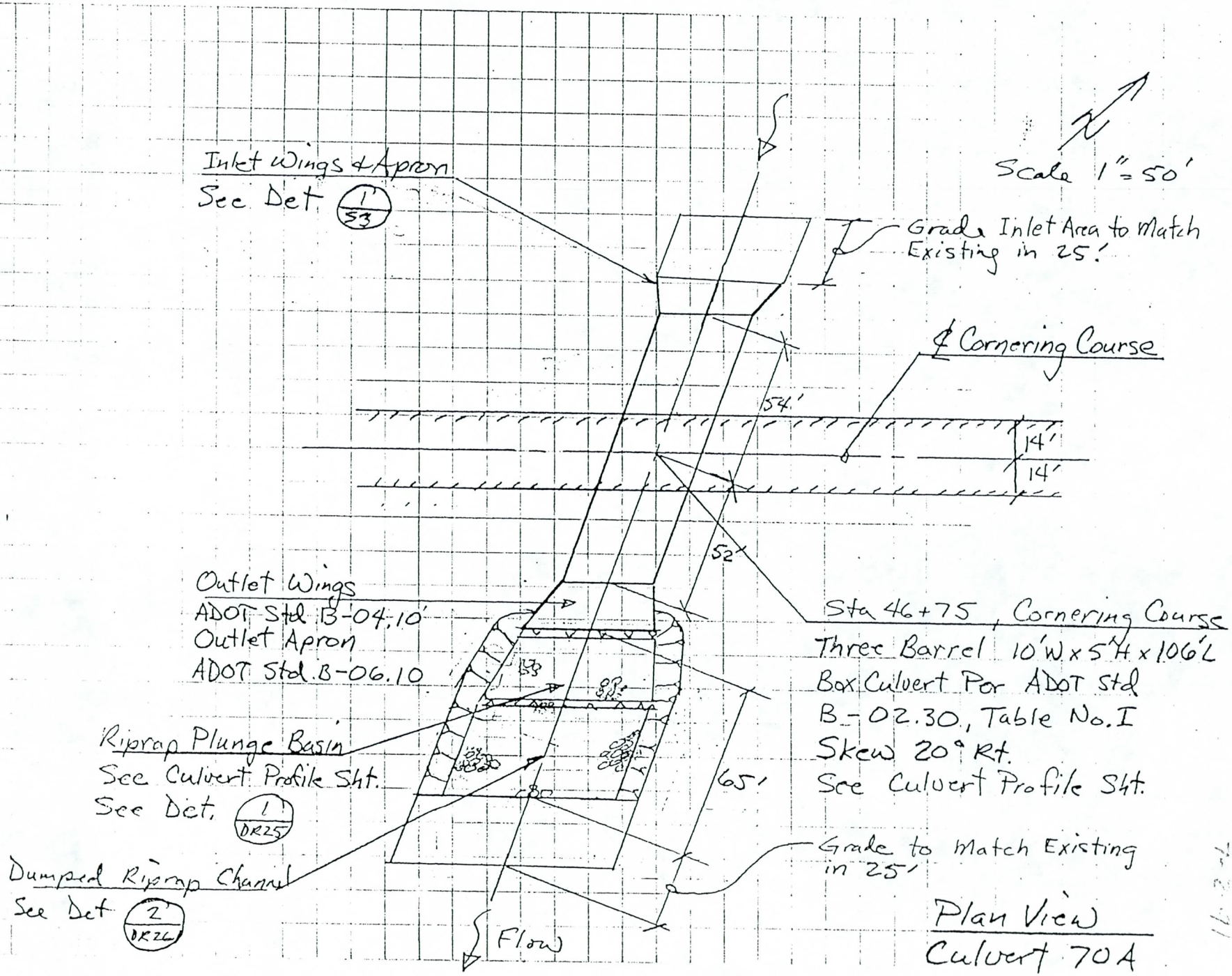
Figure XI - 3 Distribution of Centerline Velocity for Flow from Submerged Outlets from Reference XI - 2. to be used for Predicting Channel Velocities Downstream from Culvert Outlet where High Tailwater prevails. Velocities obtained from the use of this Chart can be used with Figure 2 of HEC No. 11 for sizing riprap (DO not use Figure 1 HEC No. 11, use Mean Velocity Values)

SVERDRUP

JOB 4677 Toyota SHEET NO. 10 OF

COMPUTATIONS FOR Plan View Culvert 70A DATE 6/7/91

BY BDO CHKD RJT



Plan View
Culvert 70A

SVERDRUP

JOB 40477 Toyota SHEET NO. 11 OF

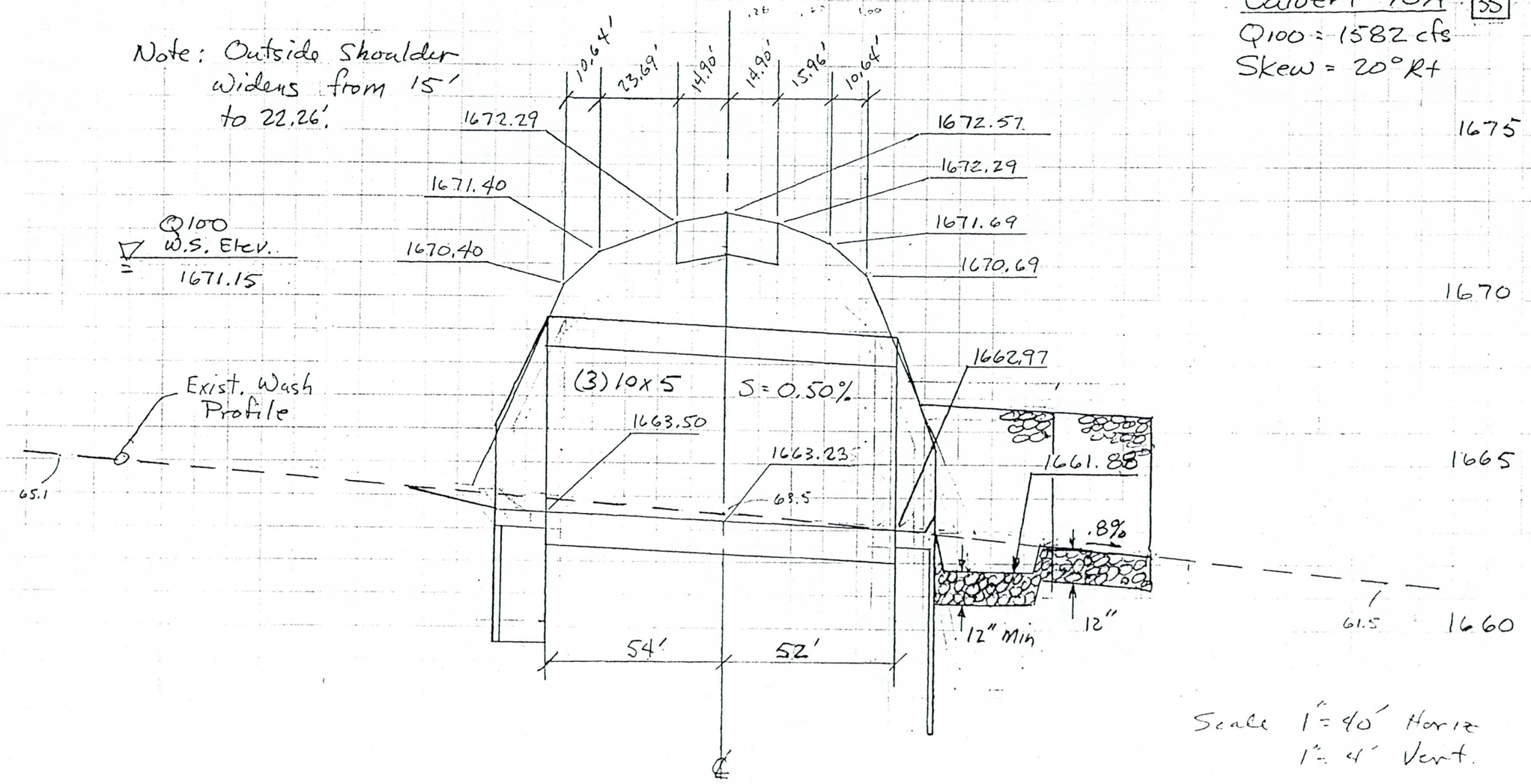
COMPUTATIONS FOR Culvert Profile 70A 35 DATE 6/2/91

Cornering Course Sta 46+75 BY BDO CHKD RJT

Culvert 70A 35

Q100 = 1582 cfs

Skew = 20° Rt



Scale 1"=40' Horiz
1"=4' Vert.

SECTION NUMBER TW70A 6/3/91

Channel Slope: 0.0097 ft./ft.

CROSS SECTION DATA:

OFFSET	1	201	284	288.2	290.4	293.8	303.7	317.6	322.1	325.4	386	475
ELEV.	66	64.32	63.85	61.49	61.5	62.78	64.31	63.73	63.01	64.02	64.88	66.5
N	N/A	0.035	0.035	0.035	0.025	0.035	0.035	0.035	0.035	0.035	0.035	0.035

STAGE-DISCHARGE DATA:

STAGE: 61.5												
WET PER.	0.0	0.0	0.0	2.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	(
AREA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	(
HYD.RAD.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	(
Q	0	0	0	0	0	0	0	0	0	0	0	

STAGE: 61.9												
WET PER.	0.0	0.0	0.8	2.2	1.1	0.0	0.0	0.0	0.0	0.0	0.0	(
AREA	0.0	0.0	0.1	0.9	0.2	0.0	0.0	0.0	0.0	0.0	0.0	(
HYD.RAD.	0.0	0.0	0.2	0.4	0.2	0.0	0.0	0.0	0.0	0.0	0.0	(
Q	0	0	0	3	0	0	0	0	0	0	0	

STAGE: 62.3												
WET PER.	0.0	0.0	1.7	2.2	2.3	0.0	0.0	0.0	0.0	0.0	0.0	(
AREA	0.0	0.0	0.6	1.8	0.9	0.0	0.0	0.0	0.0	0.0	0.0	(
HYD.RAD.	0.0	0.0	0.4	0.8	0.4	0.0	0.0	0.0	0.0	0.0	0.0	(
Q	0	0	1	9	2	0	0	0	0	0	0	

STAGE: 62.7												
WET PER.	0.0	0.0	2.5	2.2	3.4	0.0	0.0	0.0	0.0	0.0	0.0	(
AREA	0.0	0.0	1.3	2.7	1.9	0.0	0.0	0.0	0.0	0.0	0.0	(
HYD.RAD.	0.0	0.0	0.5	1.2	0.6	0.0	0.0	0.0	0.0	0.0	0.0	(
Q	0	0	4	18	5	0	0	0	0	0	0	

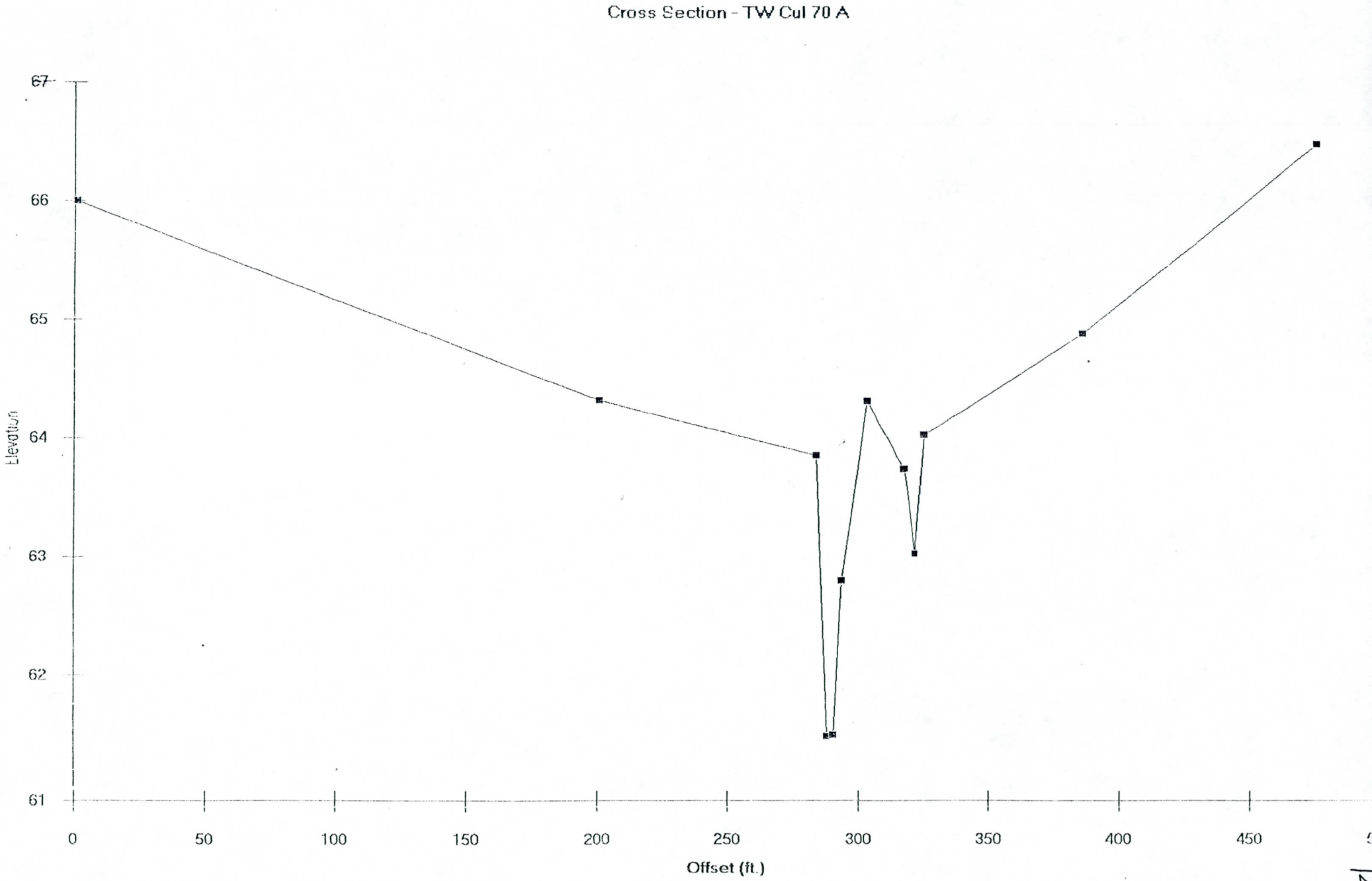
STAGE: 63.1												
WET PER.	0.0	0.0	3.3	2.2	3.6	5.7	0.0	0.6	0.9	0.0	0.0	(
AREA	0.0	0.0	2.3	3.5	3.3	3.6	0.0	0.0	0.0	0.0	0.0	(
HYD.RAD.	0.0	0.0	0.7	1.6	0.9	0.6	0.0	0.0	0.0	0.0	0.0	(
Q	0	0	8	28	0	11	0	0	0	0	0	

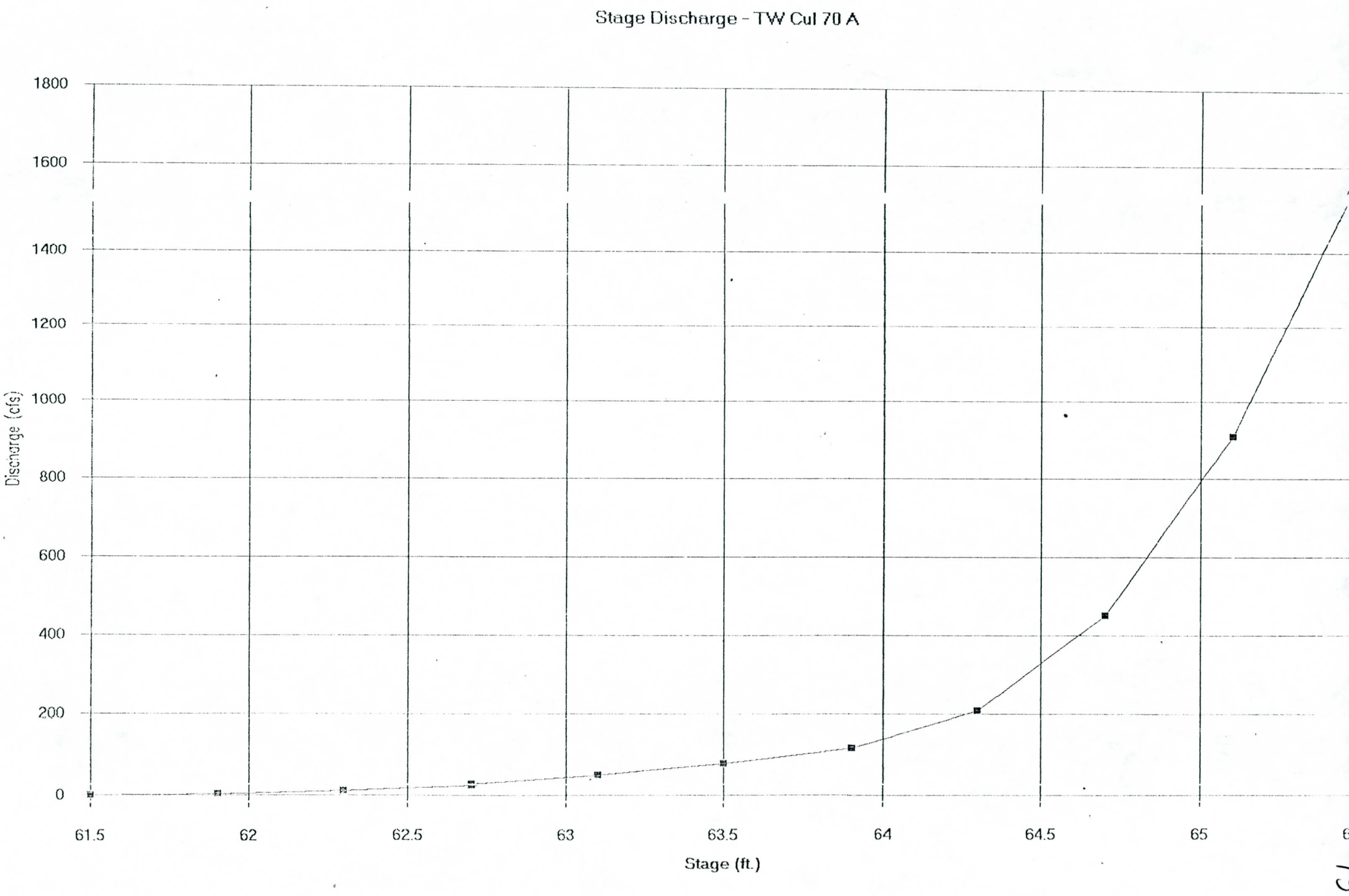
STAGE: 63.5												
WET PER.	0.0	0.0	4.1	2.2	3.6	8.3	0.0	3.1	4.8	0.0	0.0	(
AREA	0.0	0.0	3.6	4.4	4.6	6.3	0.0	0.8	1.1	0.0	0.0	(
HYD.RAD.	0.0	0.0	0.9	2.0	1.3	0.8	0.0	0.2	0.2	0.0	0.0	(
Q	0	0	14	41	0	22	0	0	2	0	0	

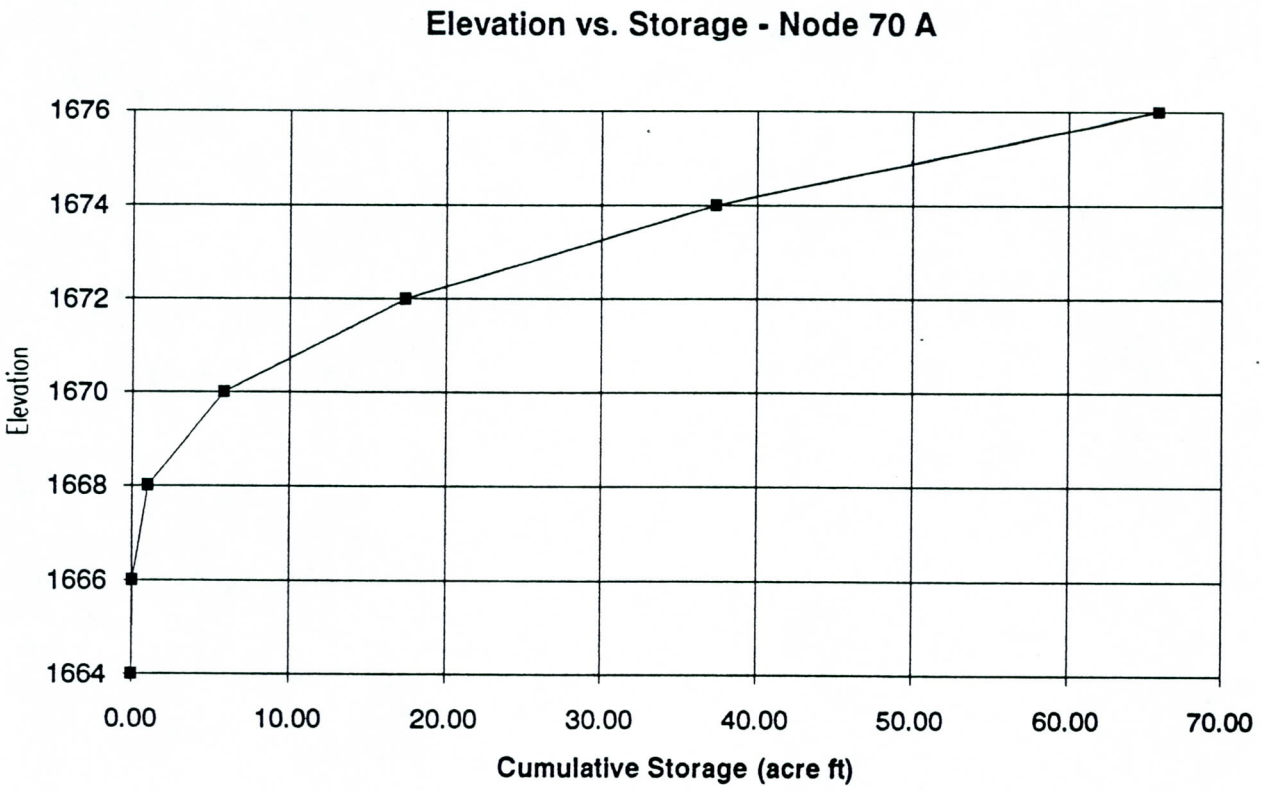
SECTION NUMBER TW70A 6/3/91

STAGE:	63.9										
WET PER.		0.0	8.8	13.6	2.2	3.6	11.0	4.1	8.6	11.7	0.0	0.0
AREA		0.0	0.2	5.4	5.3	6.0	10.0	0.3	2.7	4.0	0.0	0.0
HYD.RAD.		0.0	0.0	0.4	2.4	1.6	0.9	0.1	0.3	0.3	0.0	0.0
Q		0	0	12	56	0	40	0	0	8	0	0
STAGE:	64.3											
WET PER.		0.0	79.5	84.3	2.2	3.6	13.6	13.7	18.2	21.7	41.4	0.0
AREA		0.0	17.9	24.7	6.2	7.3	14.8	3.9	8.1	10.7	13.4	0.0
HYD.RAD.		0.0	0.2	0.3	2.8	2.0	1.1	0.3	0.4	0.5	0.3	0.0
Q		0	0	46	72	0	66	0	0	0	27	0
STAGE:	64.7											
WET PER.		45.2	128.2	133.1	2.2	3.6	13.7	27.6	32.1	35.6	83.5	0.0
AREA		8.6	59.6	68.2	7.1	8.7	20.1	29.6	35.6	39.5	55.8	0.0
HYD.RAD.		0.2	0.5	0.5	3.2	2.4	1.5	1.1	1.1	1.1	0.7	0.0
Q		0	0	182	90	0	0	0	0	0	178	0
STAGE:	65.1											
WET PER.		92.9	175.9	180.7	2.2	3.6	13.7	27.6	32.1	35.6	96.2	108.3
AREA		36.2	120.5	130.7	7.9	10.1	25.5	40.5	48.3	53.5	92.9	94.2
HYD.RAD.		0.4	0.7	0.7	3.6	2.8	1.9	1.5	1.5	1.5	1.0	0.9
Q		0	0	410	109	0	0	0	0	0	0	359
STAGE:	65.5											
WET PER.		140.5	223.5	228.3	2.2	3.6	13.7	27.6	32.1	35.6	96.2	130.2
AREA		82.9	200.3	212.2	8.8	11.4	30.8	51.4	60.9	67.5	131.1	141.7
HYD.RAD.		0.6	0.9	0.9	4.0	3.1	2.3	1.9	1.9	1.9	1.4	1.1
Q		0	0	845	130	0	0	0	0	0	0	627

W.S. Elev.	61.5	61.9	62.3	62.7	63.1	63.5	63.9	64.3	64.7	65.1	65.5
Q	0	3	12	27	47	79	116	210	450	908	1602
A	0.0	1.3	3.2	5.9	9.5	15.4	24.7	59.1	131.0	232.8	362.7
V	0.2	2.7	3.8	4.5	5.0	5.1	4.7	3.5	3.4	3.9	4.4


Cross Section - TW Cul 70 A
Elevation
67
66
65
64
63
62
61
0
50
100
150
200
250
300
350
400
450
Offset (ft.)


Stage Discharge - TW Cul 70 A
1800
1600
1400
1200
1000
800
600
400
200
0
Discharge (cfs)
61.5
62
62.5
63
63.5
64
64.5
65
Stage (ft.)


Elevation vs. Storage - Node 70 A
1676
1674
1672
1670
1668
1666
1664
Elevation
0.00
10.00
20.00
30.00
40.00
50.00
60.00
70.00
Cumulative Storage (acre ft)

SVERDRI

JOB 40477 Toyota SHEET NO. 1 OF

DATE 6/3/91

COMPUTATIONS FOR Proposed Culvert 70F 36 BY BDO CHKD RJT

CULVERT COMPUTATION SHEET

PROJECT: DESIGNER:

STATION: 58+80 DATE:

HYDROLOGIC AND CHANNEL INFORMATION

DRAINAGE AREA

Q_1 = 2528 cfs TW_1 = 4.05

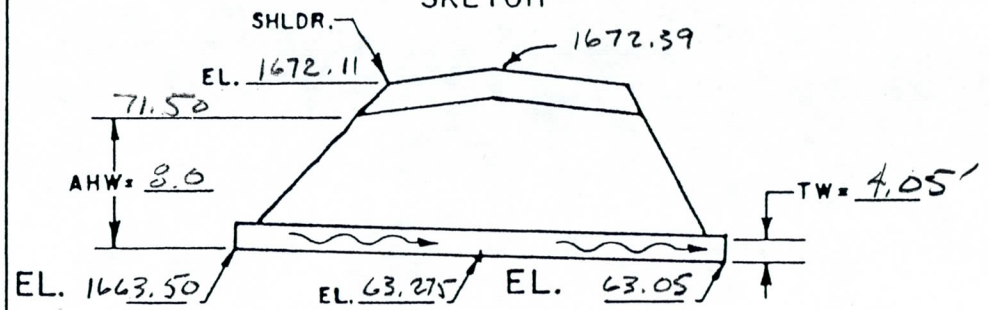
Q_2 = TW_2 =

Peak Outlet Discharge

(Q_1 = DESIGN DISCHARGE, SAY Q_{25}) Q100

(Q_2 = CHECK DISCHARGE, SAY Q_{50})

SKETCH



S_0 = .0050 L = 90' L/100 S_0 =

MEAN STREAM VELOCITY = 3.9

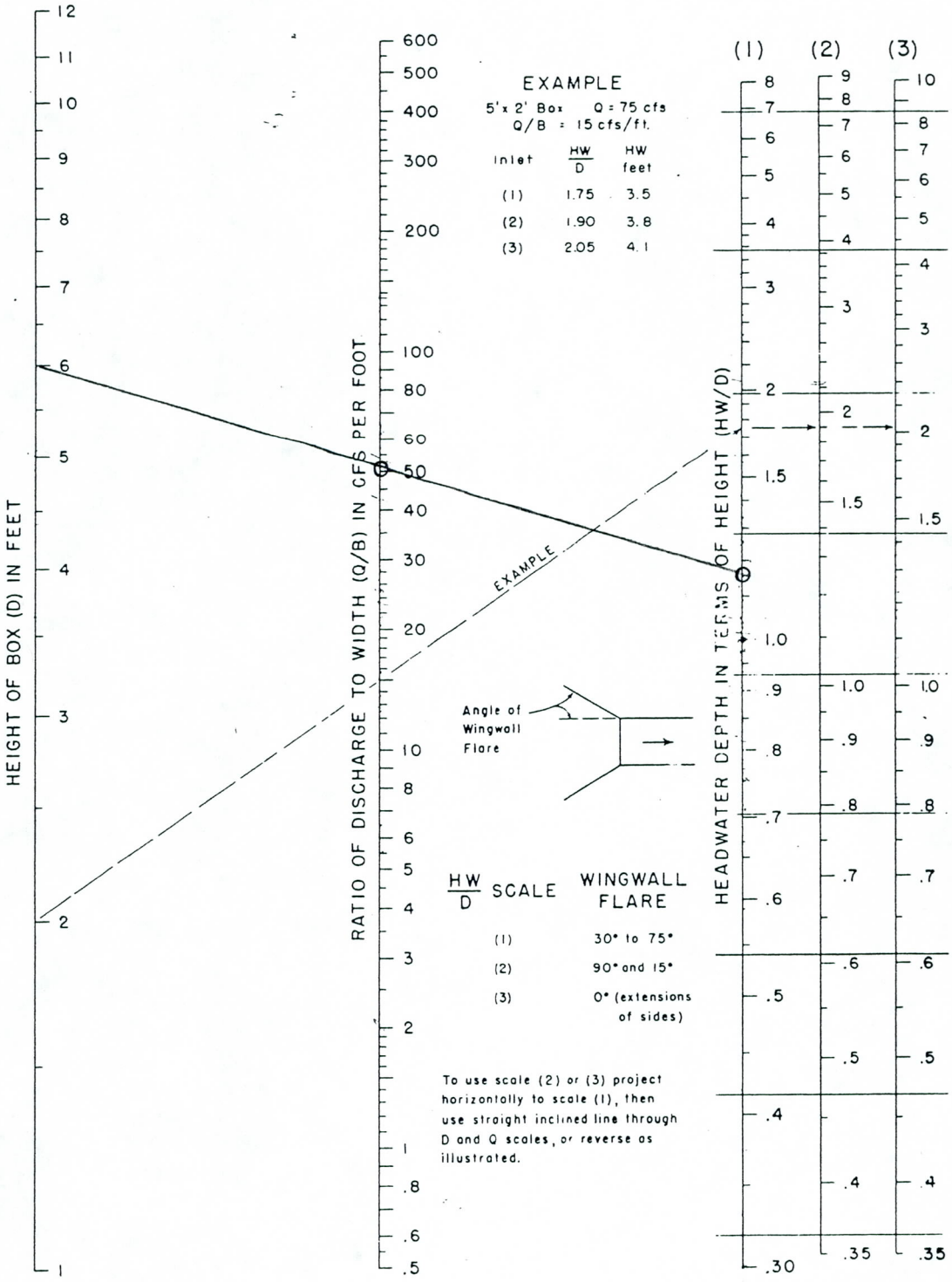
CULVERT DESCRIPTION SIZE	CULVERT DESCRIPTION ENTR. TYPE	Q	CAP. CHART HW	HEADWATER COMPUTATION: INLET CONT. HW/D	INLET CONT. HW	OUTLET CONTROL $HW = H + h_o - LS_o$: K_e	H	d_c	$\frac{d_c + D}{2}$	TW	h_o	LS_o	HW	CONTROL HW	OUTLET VELOCITY	COST	DHW ELEV.	COMMENTS
(5) Bar 10x6	45° Head walls w/ Drop Inlet	2528/5 506		1.16	6.96	0.20	1.55	4.30	5.15	4.05	5.15	0.45	6.25	6.96	14.3		1470.46	In Cot Control

SUMMARY & RECOMMENDATIONS Use soil cement channel downstream of culvert, daylight channel in 275', w/ dumped riprap to reduce outlet velocities to normal channel velocities.

B-1

Culvert 70 F

CHART I



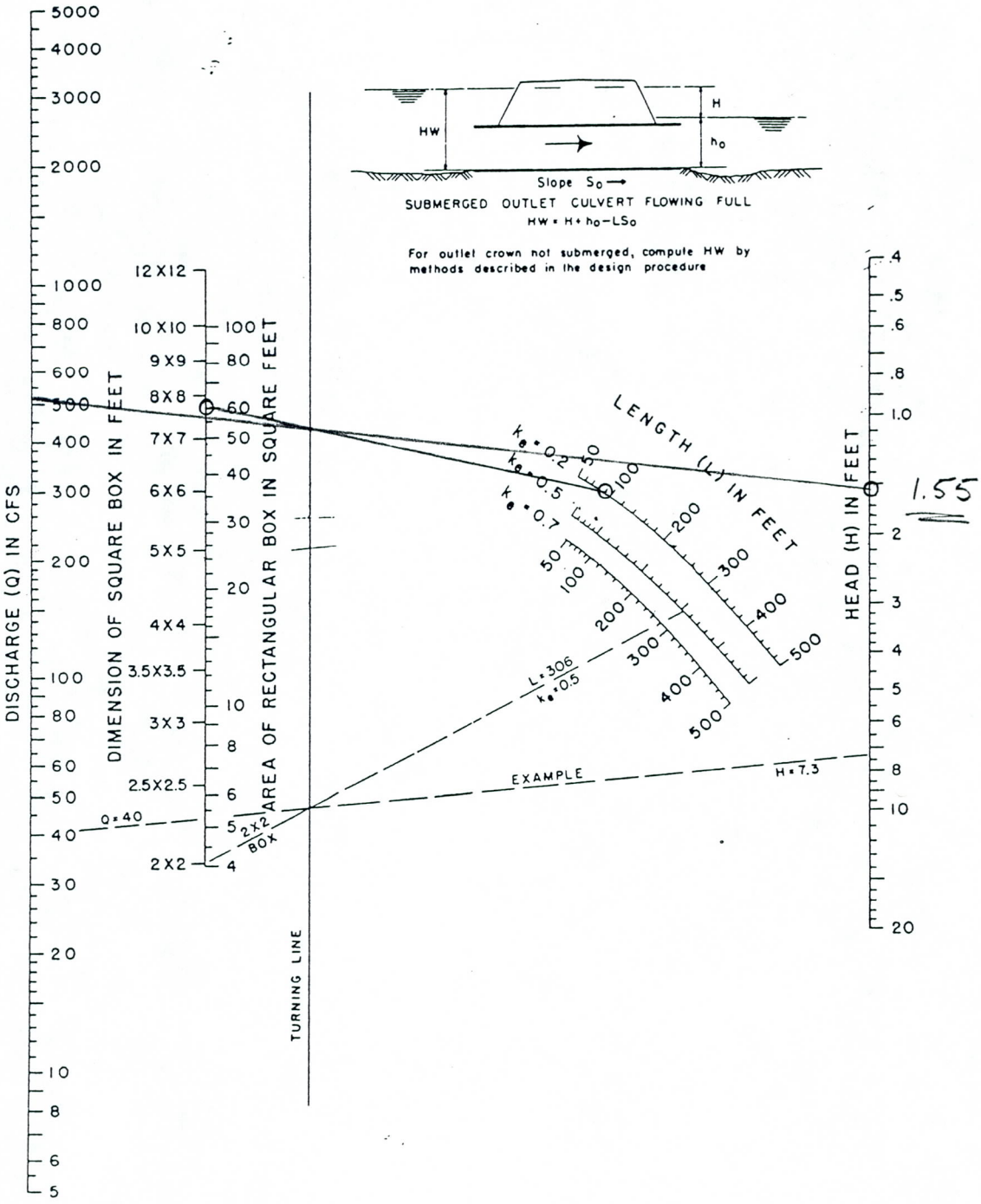
1.16

HEADWATER DEPTH FOR BOX CULVERTS WITH INLET CONTROL

BUREAU OF PUBLIC ROADS JAN. 1963

Culvert 70F

CHART 8

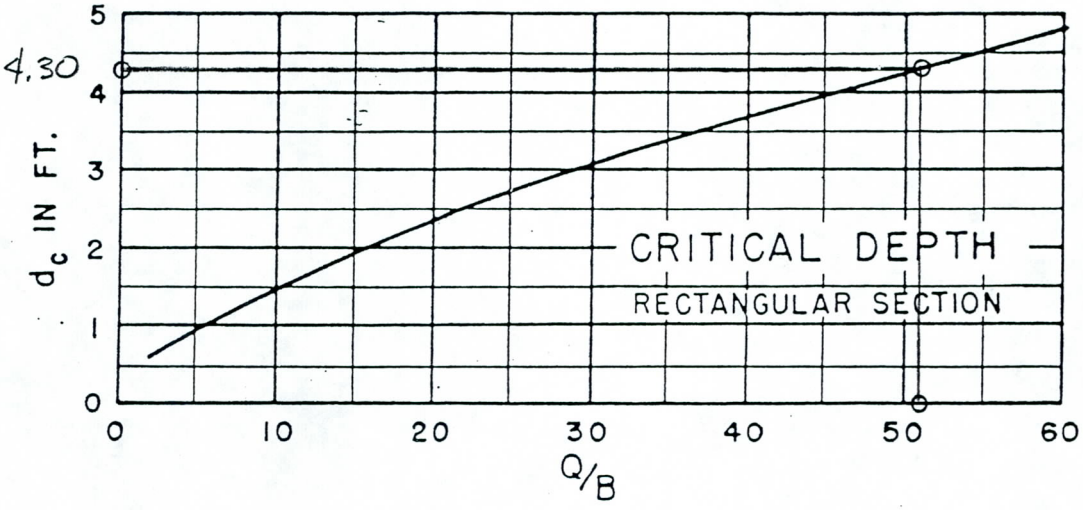


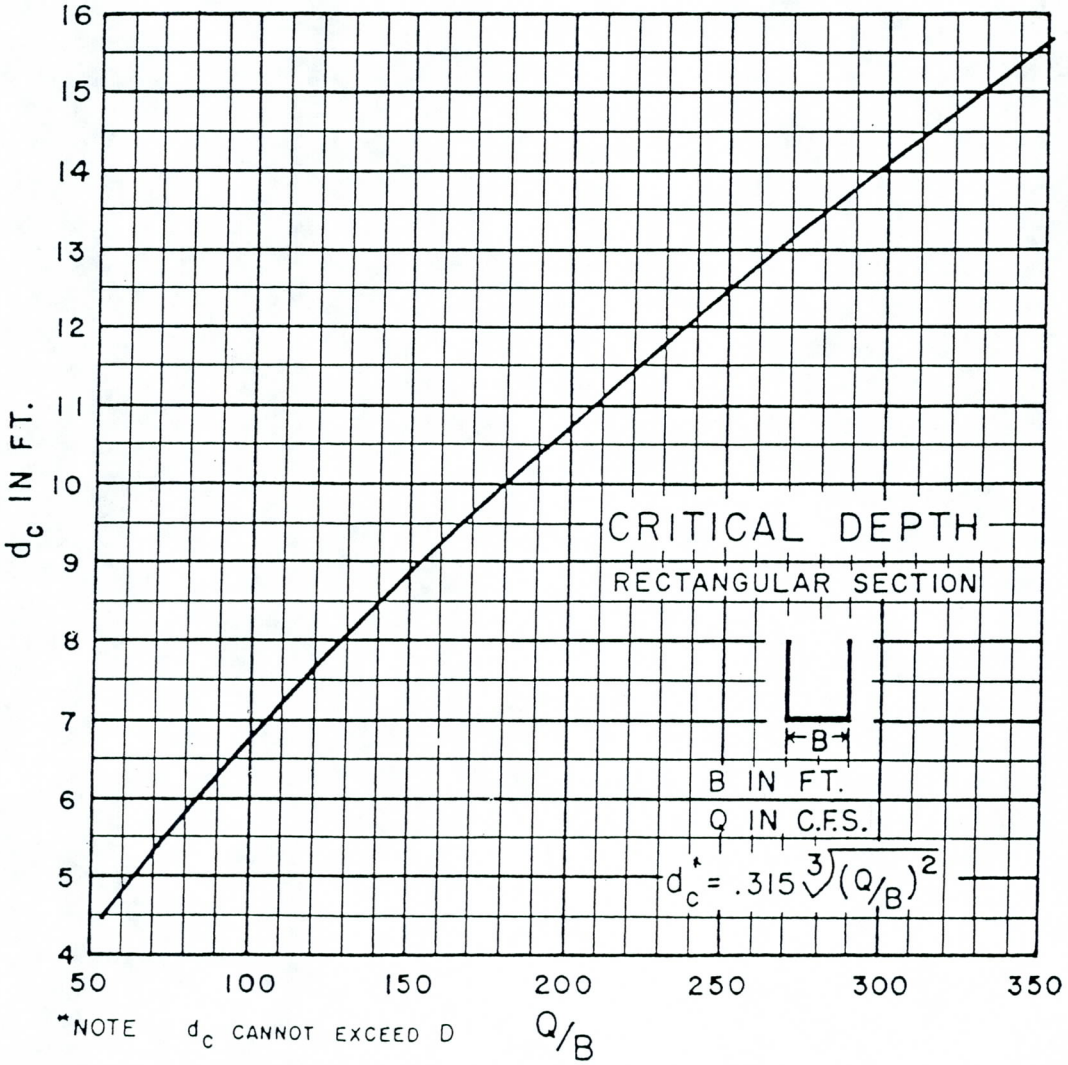
HEAD FOR
CONCRETE BOX CULVERTS
FLOWING FULL
n = 0.012

BUREAU OF PUBLIC ROADS JAN. 1963

Culvert 70 F

CHART 15





*NOTE d_c CANNOT EXCEED D

BUREAU OF PUBLIC ROADS JAN 1963

SVERDRUP

JOB 40477 Toyota

COMPUTATIONS FOR Box Culvert 70 F

SHEET NO. 5 OF

DATE 6/4/91

BY BDO CHKD RJT

Check depth of flow using Mannings Eq.

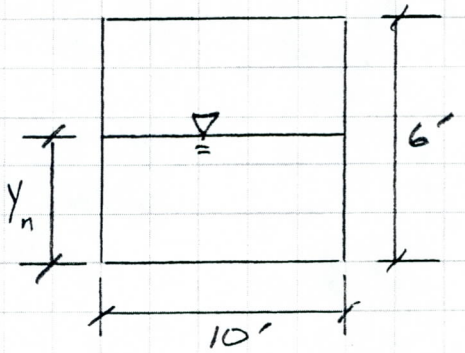
$Q_{100} = 2528$ cfs

$Q/barrel = 506$ cfs

$n = 0.012$

$S_o = 0.0050$ ft/ft

$Y_n \sim 3.56'$



$A = 35.6$ ft²

$WP = 17.12$ ft

$R_h = A/WP = \frac{35.6}{17.12} = 2.0794$

$V = \frac{1.49}{.012}(2.0794)^{.666}(.005)^{1/2} = 14.30$ fps

$Q = VA = 14.3(35.6) = 509$ cfs (OK)

Check Froude Number

$F = \frac{V}{\sqrt{g \times Y_c}} = \frac{14.30}{\sqrt{32.2 \times 3.56}} = 1.34$ Supercritical

Channel needs protection Because of Depressed Box use soil cement channel to reduce outlet velocities, Contain hydraulic jump within channel.

SVERDRUP

JOB 40477 Toyota

SHEET NO. 6 OF

DATE 6/22/91

COMPUTATIONS FOR Channel Section Downstream of Box Cul. 70 F

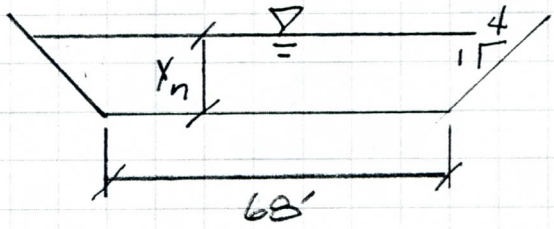
BY BDO CHKD RJT

Check depth of flow using Mannings Eqn.

$Q100 = 2528$ cfs

$n = 0.02$

$S_o = 0.0020\%$



$Y_n \sim 4.03'$

$A = 339.5\ ft^2$

$WP = 2(16.62) + 68' = 101.2\ ft$

$R_h = A/WP = 339.5/101.2 = 3.3547'$

$$V = \frac{1.49}{.02}(3.3547)^{.666}(.002)^{.5} = 7.46\ fps$$

$Q = VA = 7.46\ (339.5) = 2,533$ cfs OK

Check Froods Number $Y_c = A/T = \frac{339.5}{68+2(16.12)} = 3.39'$

$$F = \frac{V}{\sqrt{g \times Y_c}} = \frac{7.46}{\sqrt{32.2\ (3.39)}} = 0.71$$ Subcritical

Energy Grade Line $4.03 + \frac{(7.46)^2}{2(32.2)} = 4.89'$

Use 5' deep channel - Flare channel to better match existing channel area.

SVERDRUP

JOB 40477 Toyota

COMPUTATIONS FOR Channel Section DS of Culvert 70 F

SHEET NO. 2 OF

DATE 6/22/91

BY BDO CHKD RJT

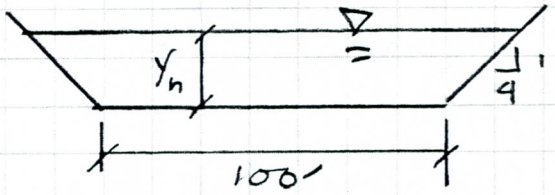
check depth of flow using Mannings Eqn.

$Q_{100} = 2528$ cfs

$n = 0.02$

$S_o = 0.002$ ft/ft

$Y_n \sim 3.29'$



$A = 371.8$ SF

$WP = 100 + 2(13.57) = 127.14'$

$R_h = A/WP = 371.8/127.1 = 2.9253'$

$V = \frac{1.49}{.02}(2.9253)^{.666}(.002)^{.5} = 6.81$ fps

$Q = VA = 6.81(371.8) = 2532$ cfs (OK)

Energy Grade Line $= 3.29 + \frac{(6.8)^2}{2(32.2)} = 4.01'$

Check cutoff Wall Depth (HEC No. 14 - Depth of Scour and Pima County DOT & FCD Design Manual)

$h_s = 0.76(3.3)\left(\frac{6.81\ (2\times(3.3)^2)}{(3.3)^{2.5}}\right)^{.375} 35^{0.1} = 7.6'$

Use 8' cutoff wall with downstream riprap protection to reduce velocity and depth of scour.

SVERDRUP

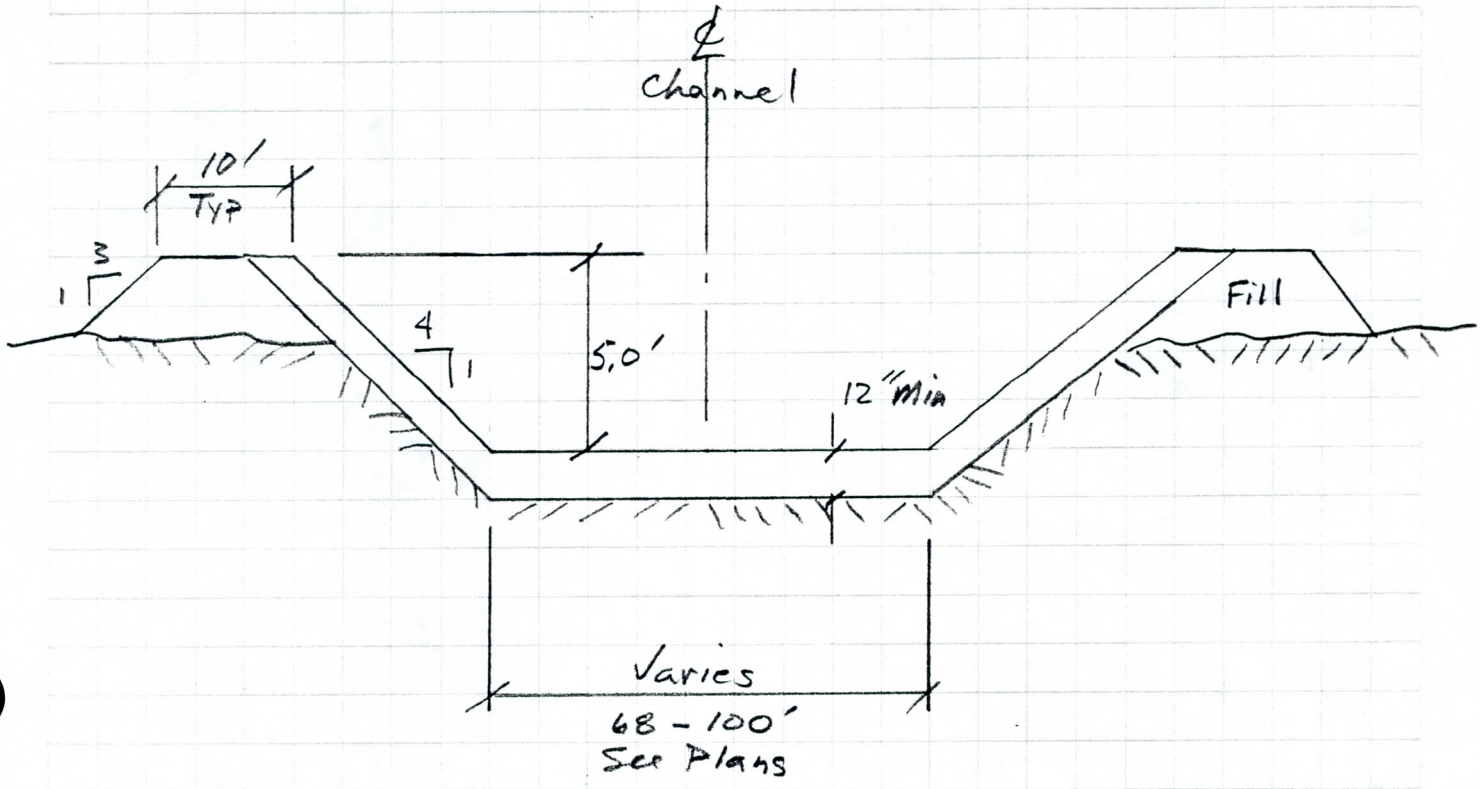
JOB 40477 Toyota

COMPUTATIONS FOR Channel Downstream Culvert 70F

SHEET NO. 8 OF

DATE 6/27/91

BY BDO CHKD RJT



Channel Section

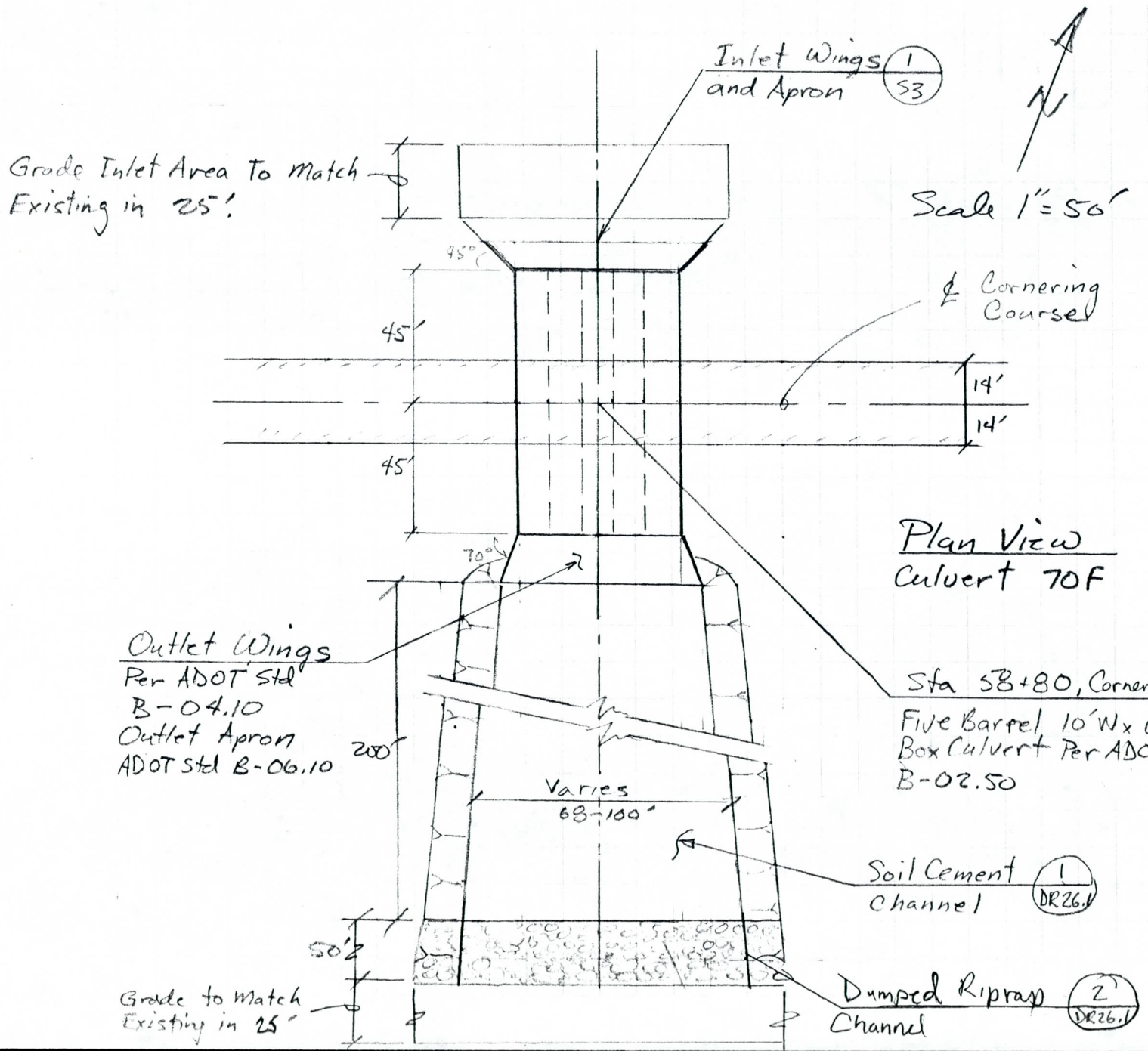
SVERDRUP

JOB 40477 Toyota SHEET NO. 1 OF

COMPUTATIONS FOR Culvert Plan View 70F DATE 6/1/94

BY BDE CHKD RJT

36



SECTION NUMBER TW70F 6/22/11

Channel Slope: 0.0075 ft./ft.

CROSS SECTION DATA:

OFFSET	0	290	370	410	430	450	548.3	582.4	584.6	589.8	592.1	637.4	640.9	644	648.7
ELEV.	68	66	65.8	64.6	65	64.7	66.28	65.82	64.37	64.81	65.59	65.89	64.21	64.29	65.8
N	N/A	0.035	0.035	0.035	0.035	0.035	0.035	0.035	0.035	0.025	0.035	0.035	0.035	0.025	0.035

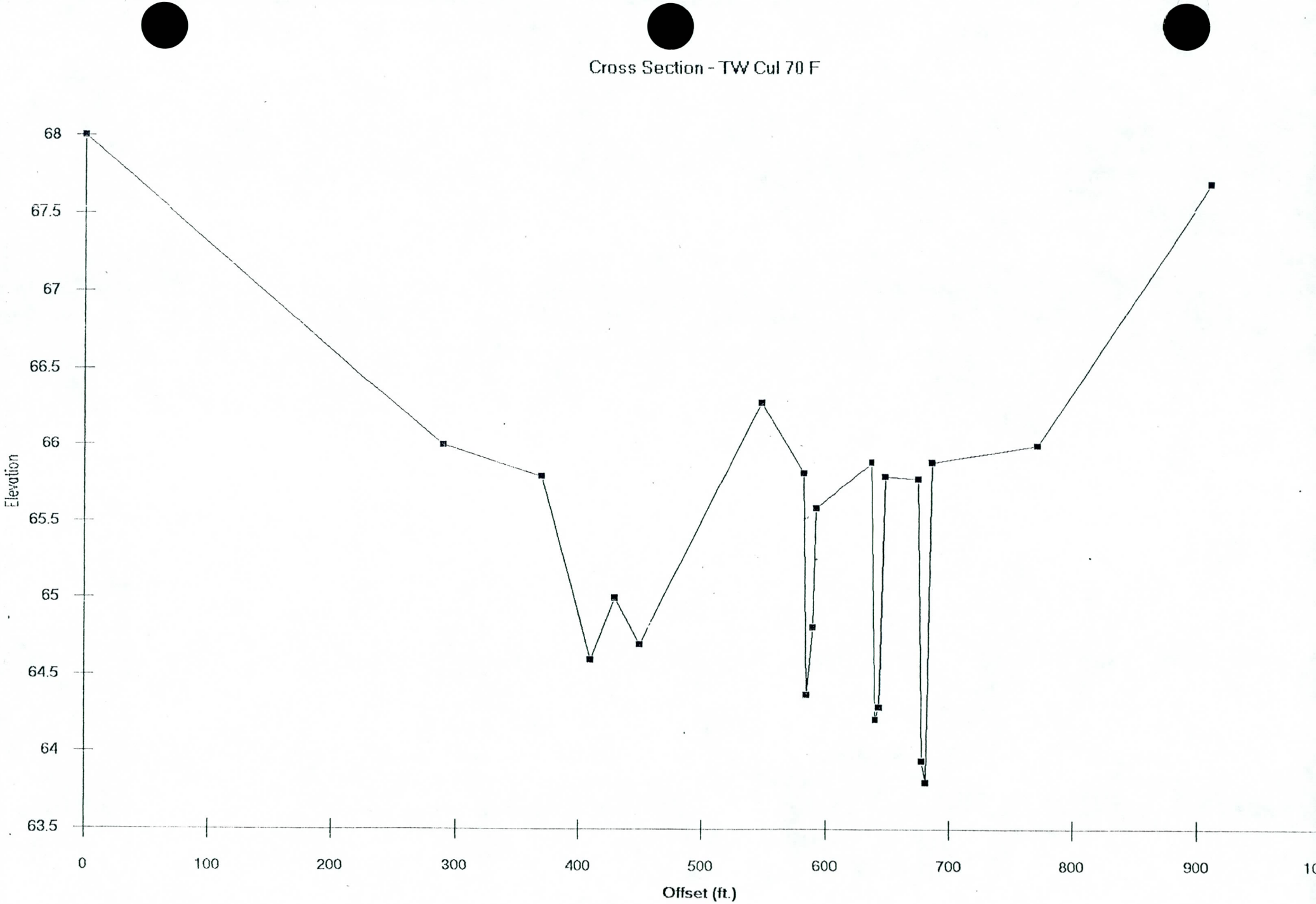
STAGE-DISCHARGE DATA:

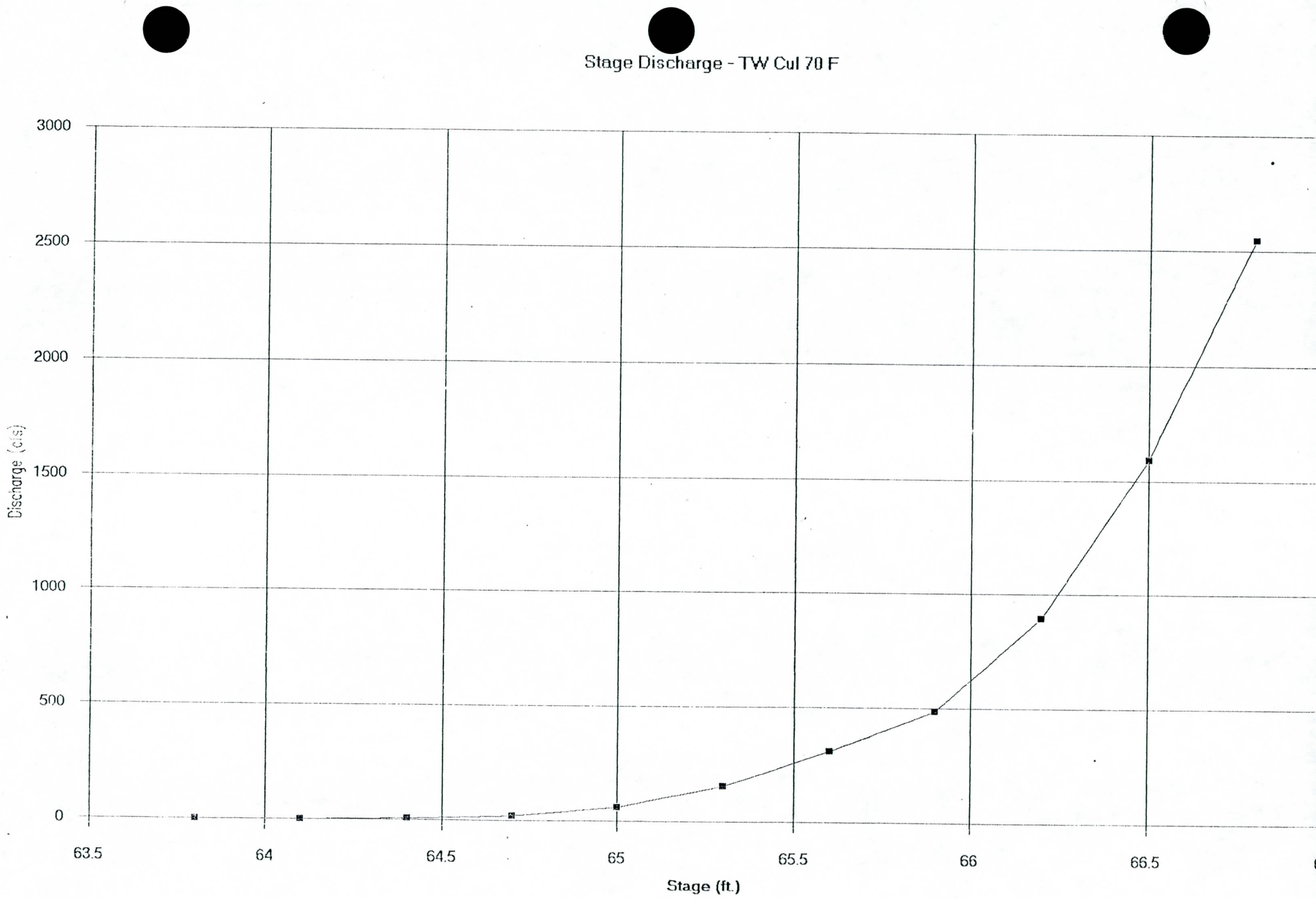
STAGE:	63.8													
WET PER.		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
AREA		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYD.RAD.		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Q		0	0	0	0	0	0	0	0	0	0	0	0	0	0
STAGE:	64.1														
WET PER.		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
AREA		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYD.RAD.		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Q		0	0	0	0	0	0	0	0	0	0	0	0	0	0
STAGE:	64.4														
WET PER.		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.4	0.0	0.0	0.4	3.1	0.4
AREA		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.0
HYD.RAD.		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1
Q		0	0	0	0	0	0	0	0	0	0	0	0	1	0
STAGE:	64.7														
WET PER.		0.0	0.0	3.3	8.3	0.0	0.0	0.0	0.6	3.9	0.0	0.0	1.1	3.1	1.3
AREA		0.0	0.0	0.2	0.4	0.0	0.0	0.0	0.1	0.6	0.0	0.0	0.3	1.4	0.3
HYD.RAD.		0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.1	0.2	0.0	0.0	0.2	0.4	0.2
Q		0	0	0	0	0	0	0	0	1	0	0	0	4	0
STAGE:	65														
WET PER.		0.0	0.0	13.3	33.3	20.0	38.7	0.0	1.1	5.2	0.6	0.0	1.8	3.1	2.3
AREA		0.0	0.0	2.7	6.7	3.0	5.8	0.0	0.3	2.1	0.1	0.0	0.7	2.3	0.8
HYD.RAD.		0.0	0.0	0.2	0.2	0.1	0.1	0.0	0.3	0.4	0.1	0.0	0.4	0.7	0.3
Q		0	0	0	8	0	6	0	0	6	0	0	1	10	1
STAGE:	65.3														
WET PER.		0.0	0.0	23.3	43.3	63.3	100.7	0.0	1.7	5.2	1.5	0.0	2.5	3.1	3.3
AREA		0.0	0.0	8.2	18.2	27.2	38.4	0.0	0.7	3.7	0.4	0.0	1.2	3.3	1.6
HYD.RAD.		0.0	0.0	0.3	0.4	0.4	0.4	0.0	0.4	0.7	0.2	0.0	0.5	1.0	0.5
Q		0	0	0	0	0	74	0	1	15	0	0	3	17	4

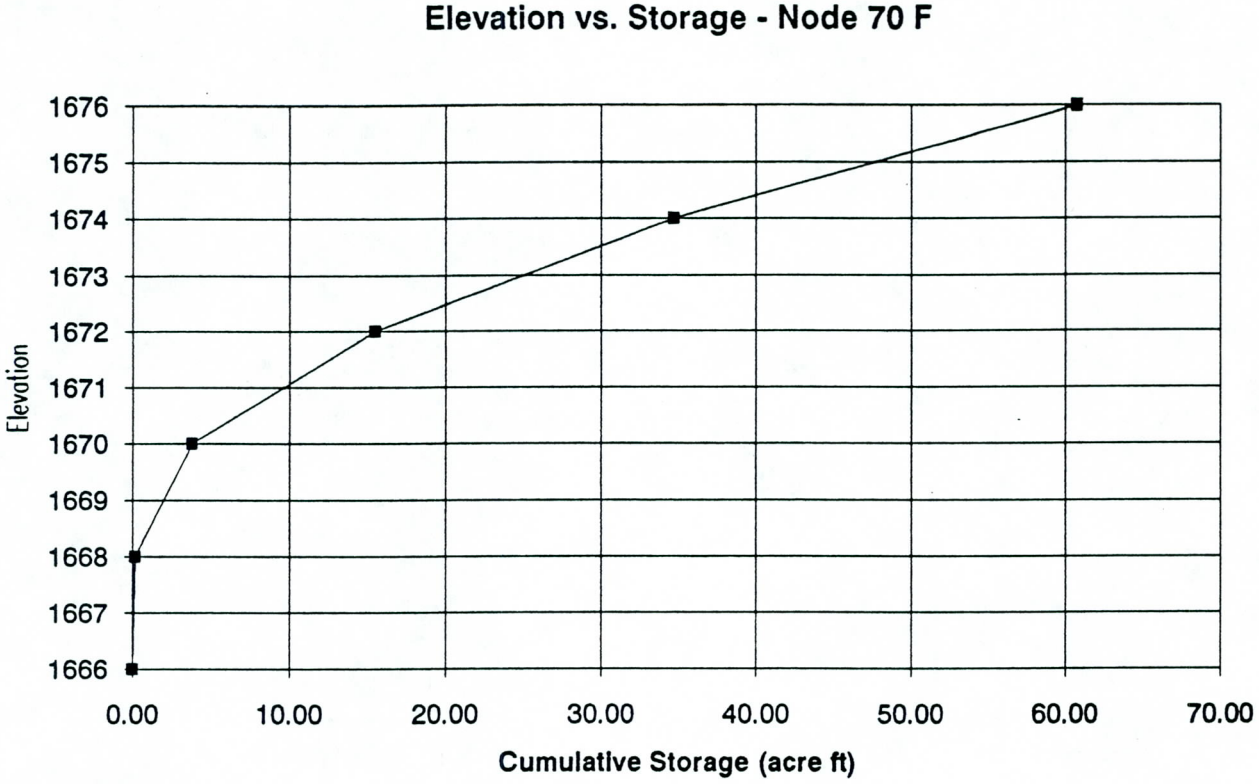
SECTION NUMBER TW70F 6/22

STAGE:	65.6													
WET PER.		0.0	0.0	33.4	53.4	73.4	129.4	0.0	2.2	5.2	2.4	3.9	3.2	3.1	4.3
AREA		0.0	0.0	16.7	32.7	47.7	72.9	0.0	1.1	5.3	0.9	0.9	2.0	4.2	2.7
HYD.RAD.		0.0	0.0	0.5	0.6	0.6	0.6	0.0	0.5	1.0	0.4	0.2	0.6	1.3	0.6
Q		0	0	0	0	0	183	0	3	27	0	1	5	26	7
STAGE:	65.9														
WET PER.		0.0	40.0	80.0	100.0	120.0	194.7	5.9	8.6	5.2	2.4	47.7	51.6	3.1	4.9
AREA		0.0	2.0	30.0	52.0	73.0	117.8	0.2	2.0	6.8	1.6	8.9	11.8	5.1	4.0
HYD.RAD.		0.0	0.1	0.4	0.5	0.6	0.6	0.0	0.2	1.3	0.7	0.2	0.2	1.6	0.8
Q		0	0	0	0	0	310	0	3	42	0	0	16	37	0
STAGE:	66.2														
WET PER.		29.0	109.0	149.0	169.0	189.0	282.4	28.2	30.8	5.2	2.4	47.7	51.6	3.1	4.9
AREA		2.9	26.9	66.9	94.9	121.9	191.9	5.4	7.8	8.4	2.3	23.1	27.2	6.0	5.4
HYD.RAD.		0.1	0.2	0.4	0.6	0.6	0.7	0.2	0.3	1.6	0.9	0.5	0.5	1.9	1.1
Q		0	0	0	0	0	545	0	11	59	0	0	65	49	0
STAGE:	66.5														
WET PER.		72.5	152.5	192.5	212.5	232.5	330.8	364.9	367.6	5.2	2.4	47.7	51.6	3.1	4.9
AREA		18.1	66.1	118.1	152.1	185.1	284.4	299.8	302.8	9.9	3.0	37.4	42.5	7.0	6.8
HYD.RAD.		0.3	0.4	0.6	0.7	0.8	0.9	0.8	0.8	1.9	1.2	0.8	0.8	2.2	1.4
Q		0	0	0	0	0	0	0	979	79	0	0	137	62	0
STAGE:	66.8														
WET PER.		116.0	196.0	236.0	256.0	276.0	374.3	408.4	411.1	5.2	2.4	47.7	51.6	3.1	4.9
AREA		46.4	118.4	182.4	222.4	261.4	390.2	415.7	419.5	11.5	3.7	51.7	57.8	7.9	8.2
HYD.RAD.		0.4	0.6	0.8	0.9	0.9	1.0	1.0	1.0	2.2	1.5	1.1	1.1	2.5	1.7
Q		0	0	0	0	0	0	0	1563	100	0	0	229	76	0

W.S. Elev.	63.8	64.1	64.4	64.7	65	65.3	65.6	65.9	66.2	66.5	66.8
Q	0	1	7	21	59	155	311	486	895	1591	2545
A	0.0	0.8	2.8	7.0	24.8	57.7	100.5	165.1	298.7	466.5	655.1
V	0.0	1.8	2.6	2.9	2.4	2.7	3.1	2.9	3.0	3.4	3.9


Cross Section - TW Cul 70 F
Elevation
68
67.5
67
66.5
66
65.5
65
64.5
64
63.5
0
100
200
300
400
500
600
700
800
900
Offset (ft.)


Stage Discharge - TW Cul 70 F
3000
2500
2000
1500
1000
500
0
Discharge (c.f.s)
63.5
64
64.5
65
65.5
66
66.5
Stage (ft.)


Elevation vs. Storage - Node 70 F
1676
1675
1674
1673
1672
1671
1670
1669
1668
1667
1666
Elevation
0.00
10.00
20.00
30.00
40.00
50.00
60.00
70.00
Cumulative Storage (acre ft)

SVERDRUP

JOB 4C[redacted] Toyota

SHEET NO [redacted]/1 OF _____

DATE [redacted]2/3/91

COMPUTATIONS FOR Proposed Culvert 70B 37

BY BDO CHKD RJT

CULVERT COMPUTATION SHEET

PROJECT: _____

STATION: 14+00

DESIGNER: _____

DATE: _____

HYDROLOGIC AND CHANNEL INFORMATION

DRAINAGE AREA _____

Q_1 = 1379 cfs

Q_2 = _____

TW_1 = 2.6'

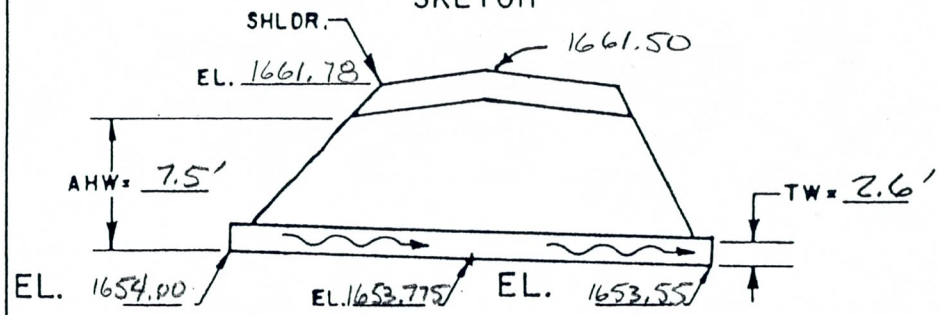
TW_2 = _____

Peak Outlet Discharge

(Q_1 = DESIGN DISCHARGE, SAY Q_{25}) Q_{100}

(Q_2 = CHECK DISCHARGE, SAY Q_{50})

SKETCH



S_o = .00550 ft/ft L = 90' L/100 S_o = _____

MEAN STREAM VELOCITY = 2.9

CULVERT DESCRIPTION		Q	CAP. CHART HW	HEADWATER COMPUTATION										CONTROL HW	OUTLET VELOCITY	COST	DHW ELEV.	COMMENTS
				INLET CONT.		OUTLET CONTROL HW = H + h_o − LS_o												
SIZE	ENTR. TYPE			HW/D	HW	K_e	H	d_c	$\frac{d_c + D}{2}$	TW	h_o	LS_o	HW					
(3)10x5	45° Wingwalls	1379/3 = 460		1.36	6.80	0.20	1.90	4.00	4.50	2.6	4.50	0.45	5.95	6.80	13.9		1660.80	Inlet Control

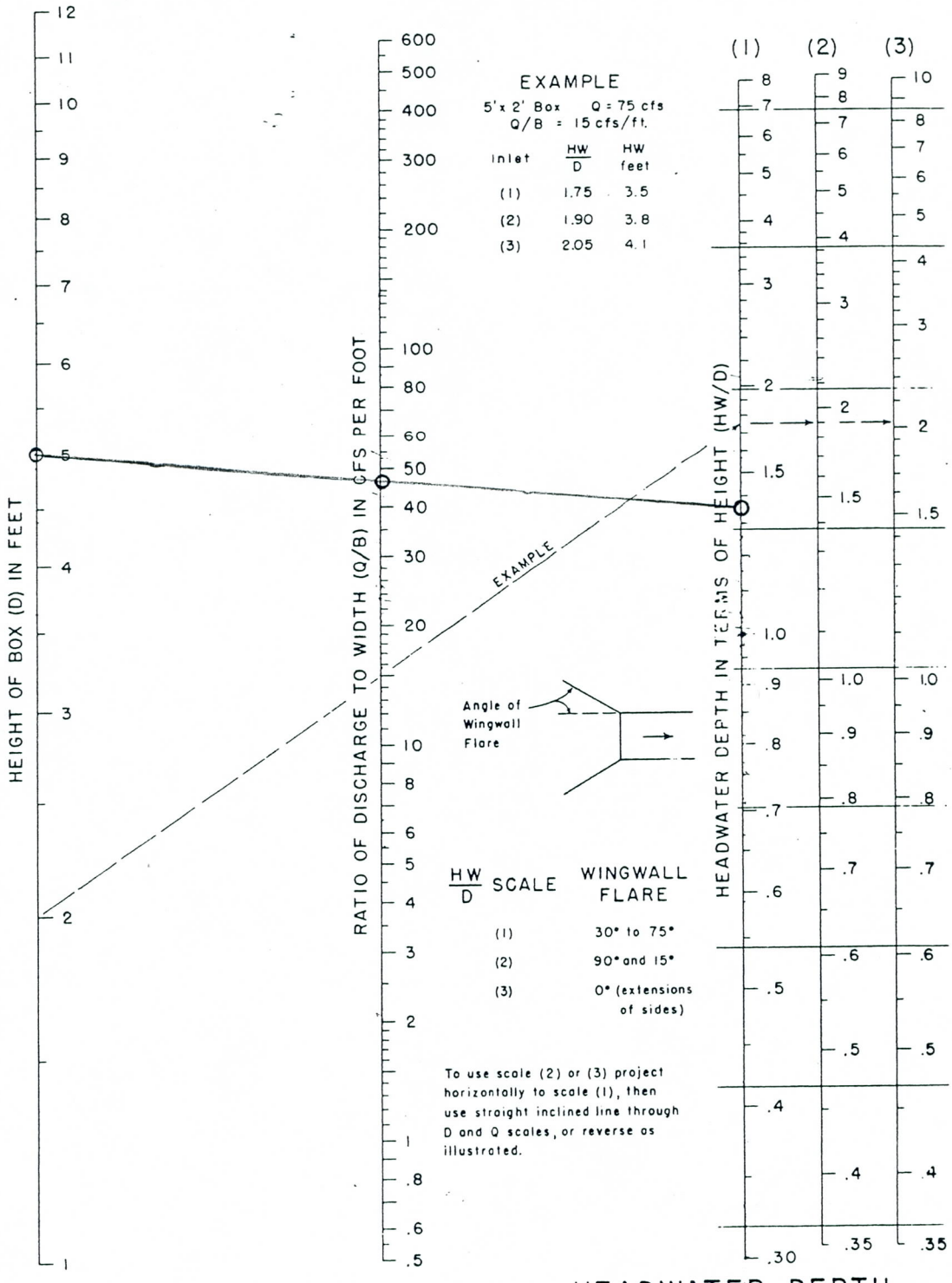
SUMMARY & RECOMMENDATIONS

Use riprap apron for erosion control designed for Q10

B-1

Culvert 70 B

CHART 1



1.36

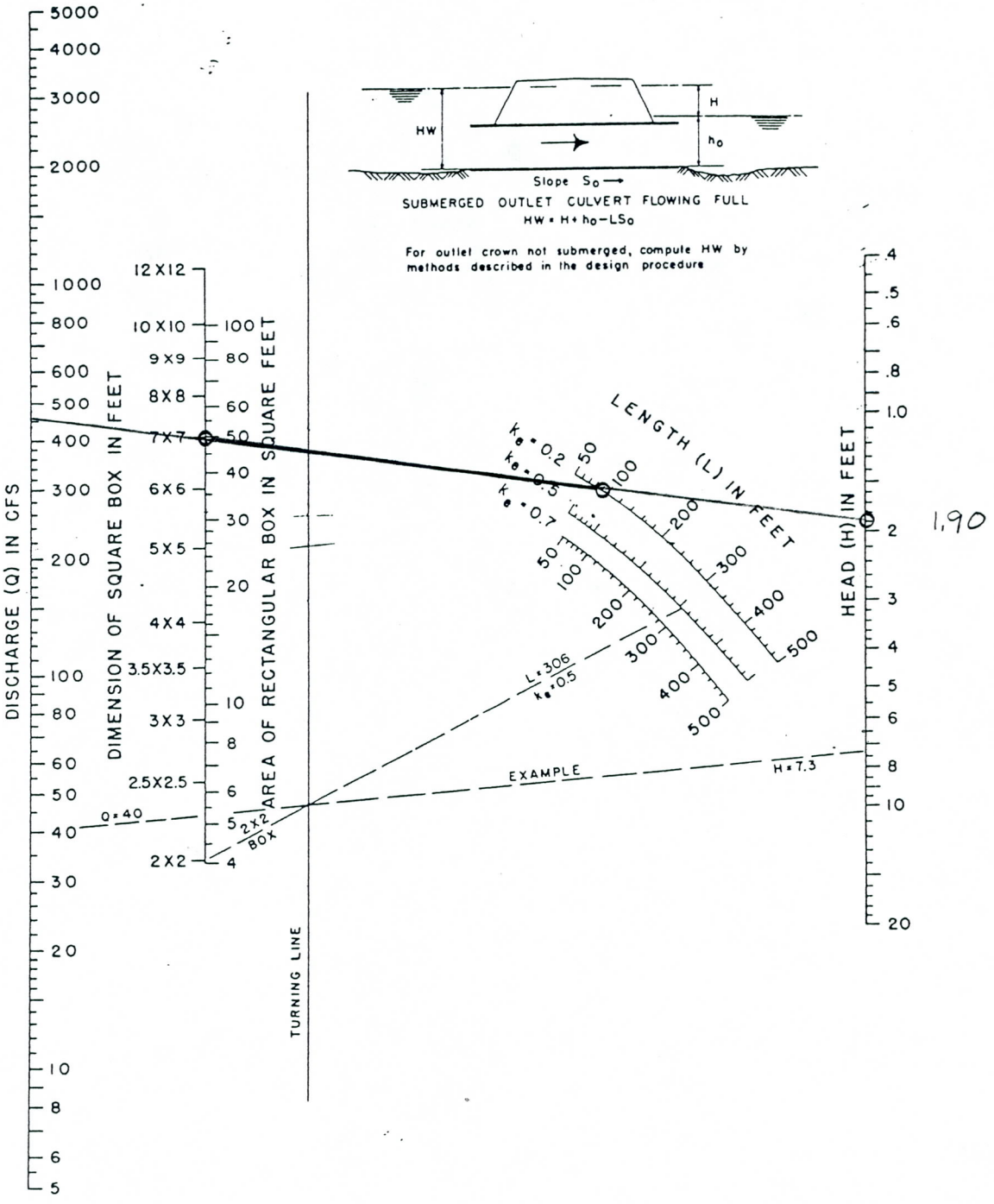
HEADWATER DEPTH FOR BOX CULVERTS WITH INLET CONTROL

BUREAU OF PUBLIC ROADS JAN. 1963

3

CULVERT 70 B

CHART 8

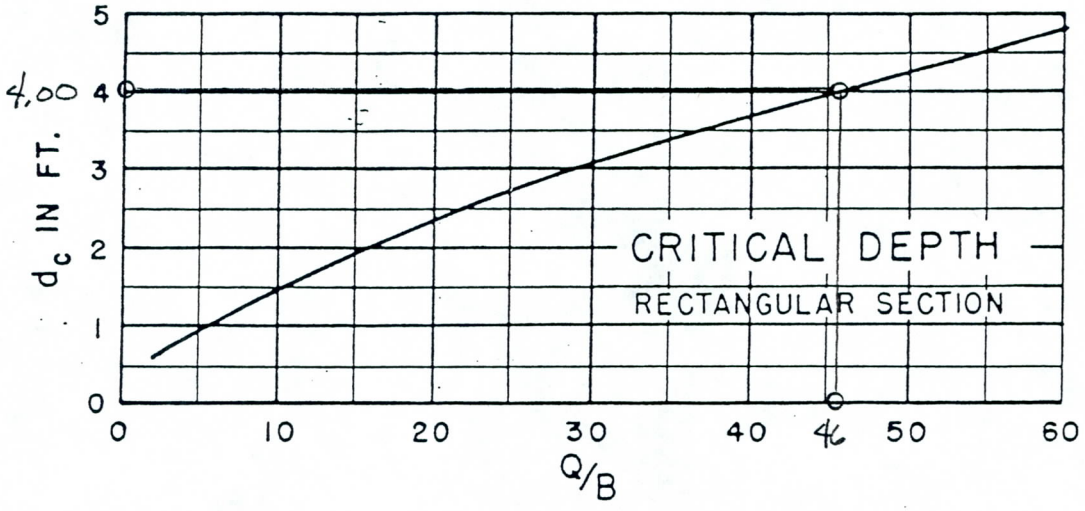


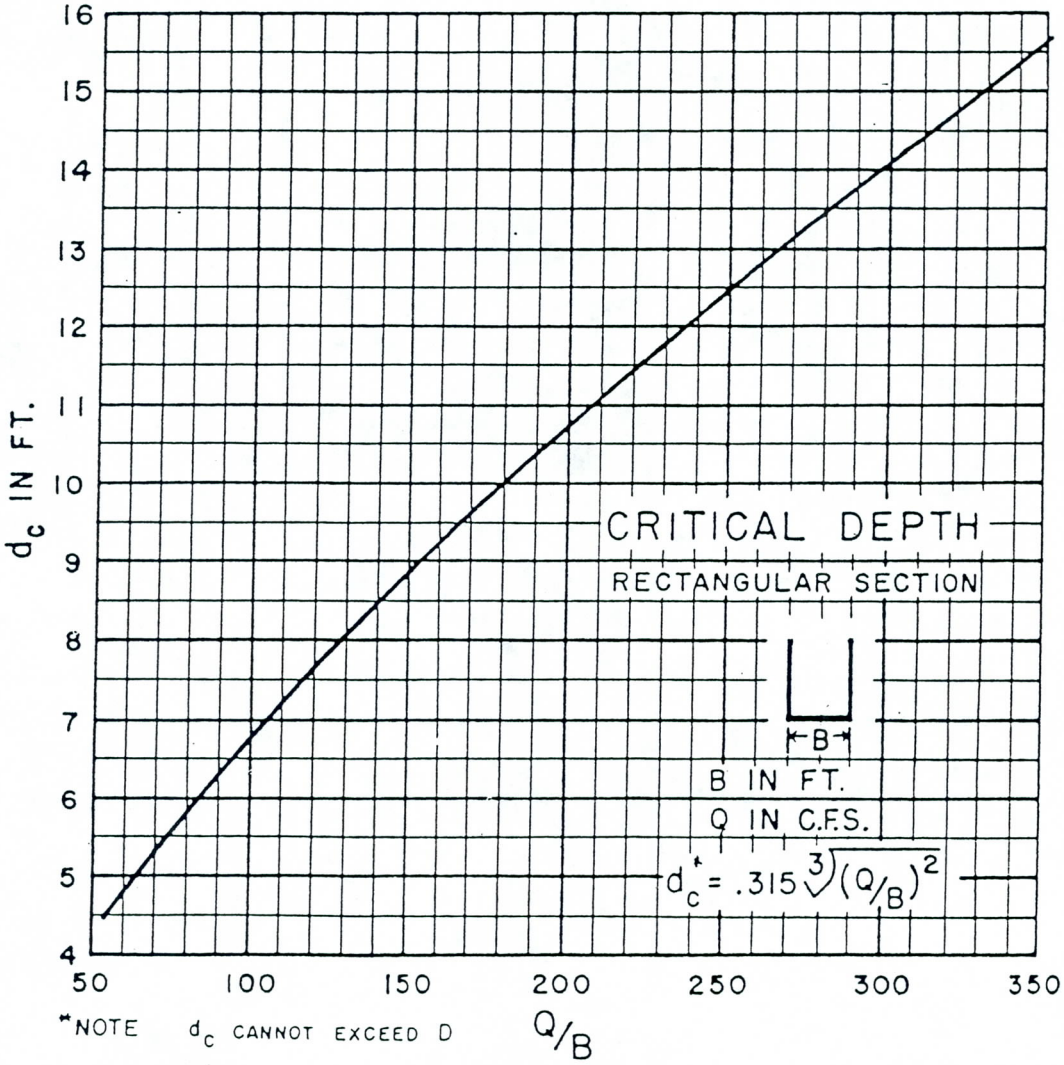
HEAD FOR
CONCRETE BOX CULVERTS
FLOWING FULL
n = 0.012

BUREAU OF PUBLIC ROADS JAN. 1963

Culvert 70 B

CHART 15





BUREAU OF PUBLIC ROADS JAN 1963

SVERDRUP

JOB 40477 Toyota SHEET NO. 5 OF

COMPUTATIONS FOR Box Culvert 70B DATE 6/4/91 BY BDO CHKD RJT

Check depth of flow using Manning Equation

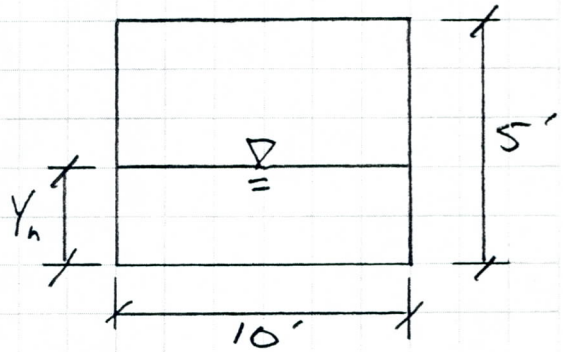
$Q_{100} = 1379$ cfs

$Q/_{barrel} = 460$ cfs

$n = 0.012$

$S_o = 0.0050\%$

$Y_n \approx 3.30'$



$A = 33.0$ ft^2

$WP = 16.60$ ft

$R_h = A/WP = 33.0/16.60 = 1.9880'$

$$V = \frac{1.49}{.012}(1.9880)^{.666}(.005)^{1/2} = 13.87 \text{ fps}$$

$Q = VA = 13.87(33.0) = 458$ cfs ≈ 460 cfs (OK)

Check Froude Number

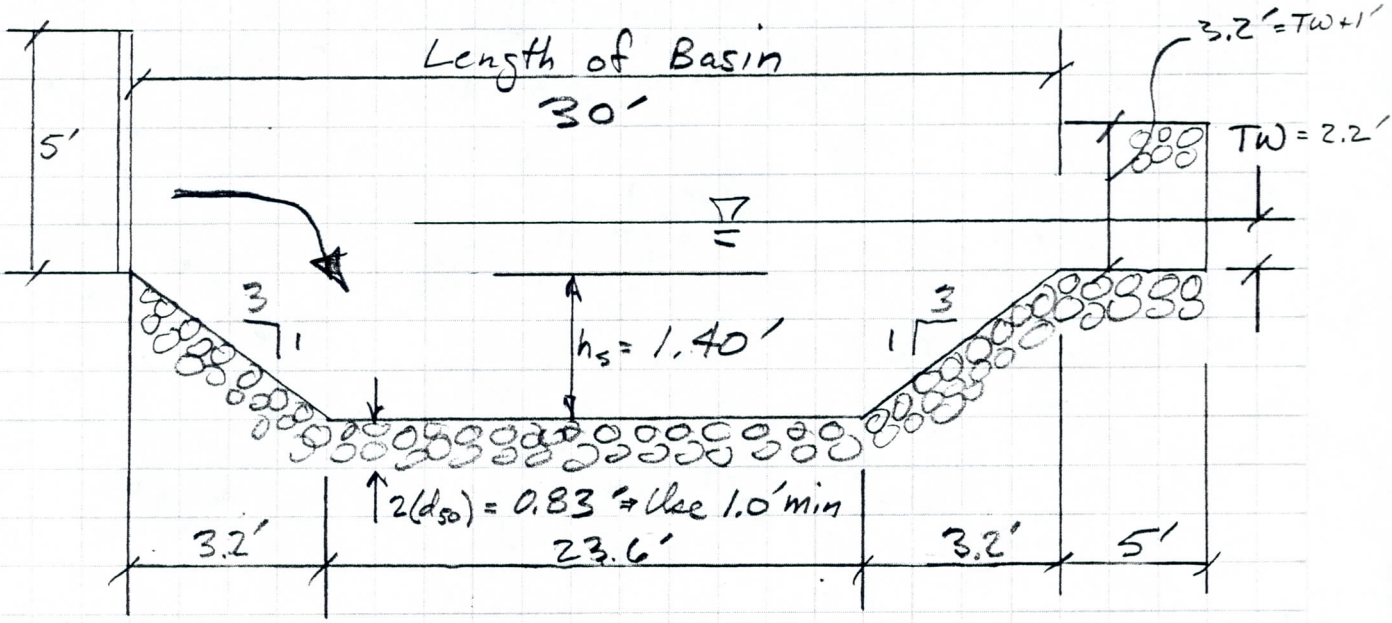
$$F = \frac{V}{\sqrt{g\,Y_e}} = \frac{13.87}{\sqrt{32.2 \times 3.30}} = 1.35, \text{ Supercritical}$$

Channel needs protection, Use Grouted Riprap Plunge Basin $F < 3.0$ OK.

For $Q_{10} = 390$ cfs 130 cfs/barrel

$Y_n = 1.40$ ft, Vel. $= 9.30$ fps, $F = 1.39$, Supercritical

Riprap Plunge Basin Design (Q10)



Check Rock Size (From Figure XI-2, HEC No 14)

For Y_o = 1.40' d_{50} = 5" or 0.42'

$d_{50}/Y_o = \frac{0.42}{1.40'} = 0.30$, $F = 1.39$

$\frac{h_s}{Y_o} = 1.00$ $h_s = 1.00(1.40) = 1.40'$

Check $\frac{h_s}{d_{50}} = \frac{1.40}{0.42} = 3.33 > 2 \& < 4$ ∴ OK

Length of Basin

$10\,h_s = 10(1.40) = 14.0'$

or

$3(w_o) = 3(10) = 30$ Use 30'

Culvert 70B

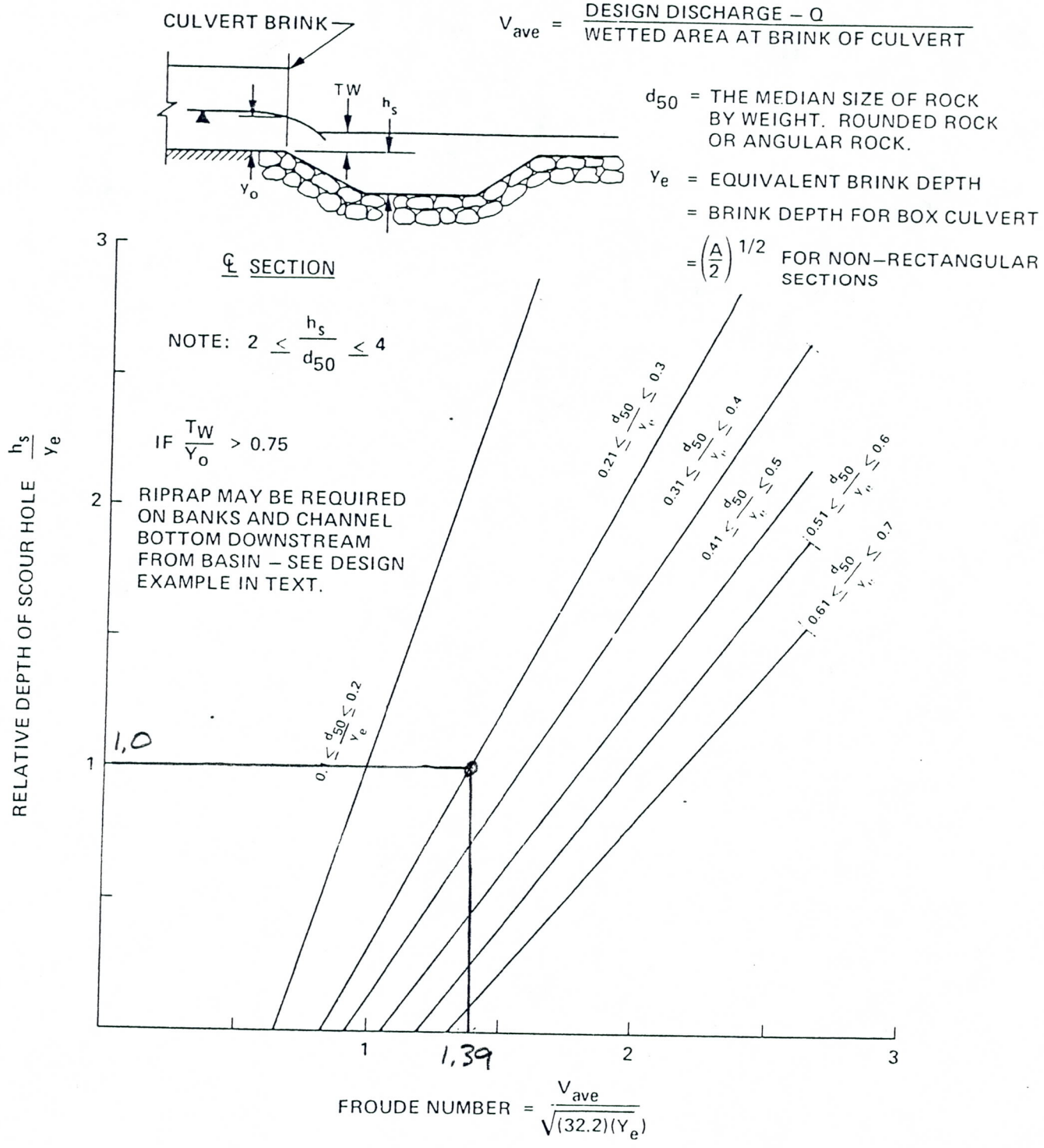


FIGURE X1–2. RELATIVE DEPTH OF SCOUR HOLE VERSUS FROUDE NUMBER AT BRINK OF CULVERT WITH RELATIVE SIZE OF RIPRAP AS A THIRD VARIABLE

$\frac{TW}{Y_o} = \frac{2.2'}{1.4} = 1.57 > 0.75$ ∴ check downstream riprap lining for channel protection.

Utilize figure XI-3 for estimating average velocity along channel. Compute equivalent circular diam. D_e for brink area from:

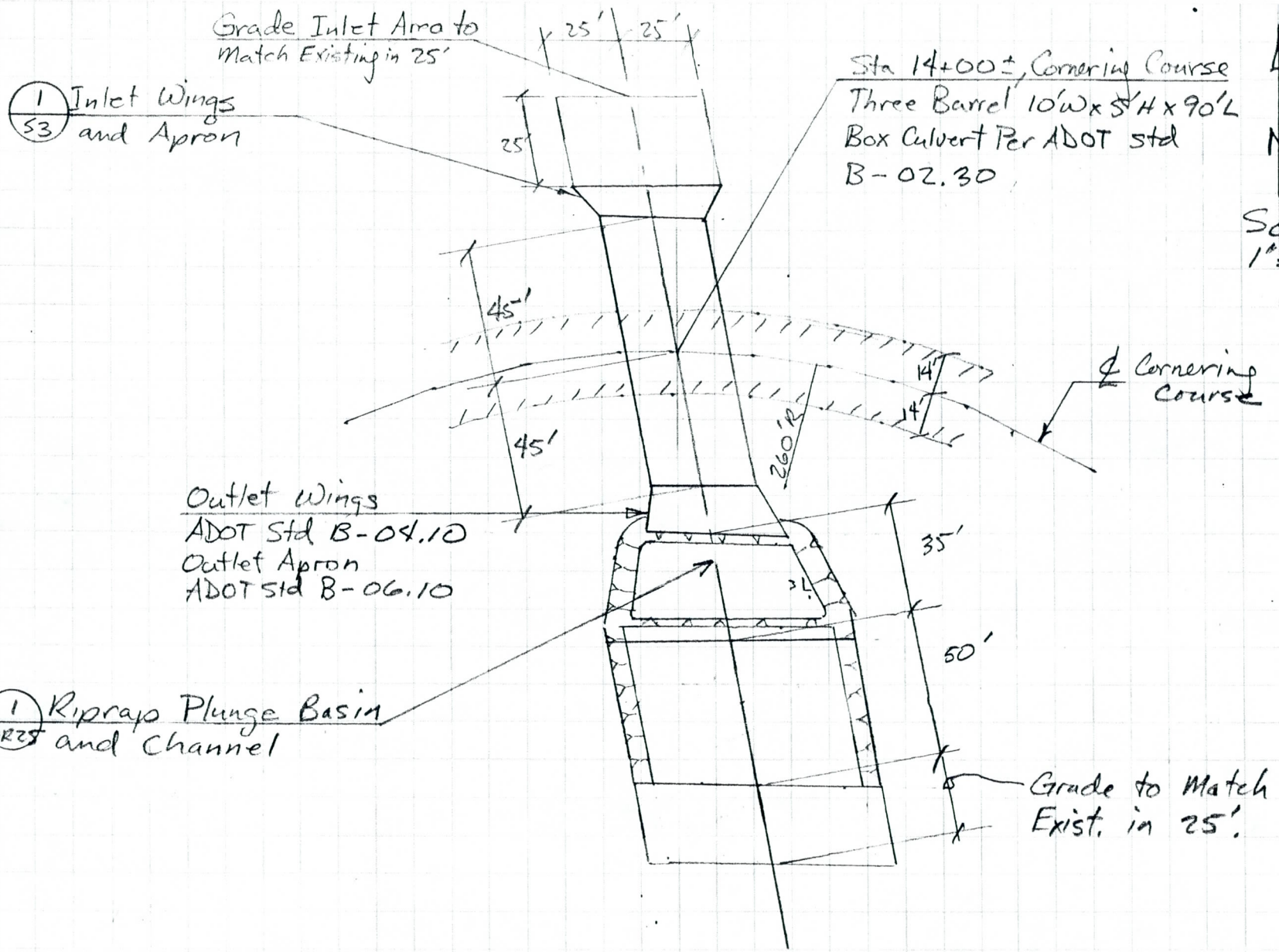
$A = \pi D_e^2/4 = Y_o(W_o) = 1.4(10) = 14.0\ ft^2$

$D_e = (14.0(4)/\pi)^{1/2} = 4.22'$

From downstream cross section @10 Velocity is 2.3 fps. Culvert outlet velocity is 9.3 fps.

L/D_e	L	V_L/V_o	V_L
10	42.2	.59	5.5 fps
15	63.3	.36	3.3 fps
20	84.4	.30	2.8 fps ~ 2.3 fps OK

∴ Need riprap lining for approximately 85 feet from the end of the culvert outlet apron.



SVERDRUP

JOB 40477 Toyota

COMPUTATIONS FOR Plan View 70B 37

SHEET NO. 9 OF

DATE 6/11/91

BY BDO CHKD RJT

SVERDRUP

JOB 40477 Toyota SHEET NO. 10 OF

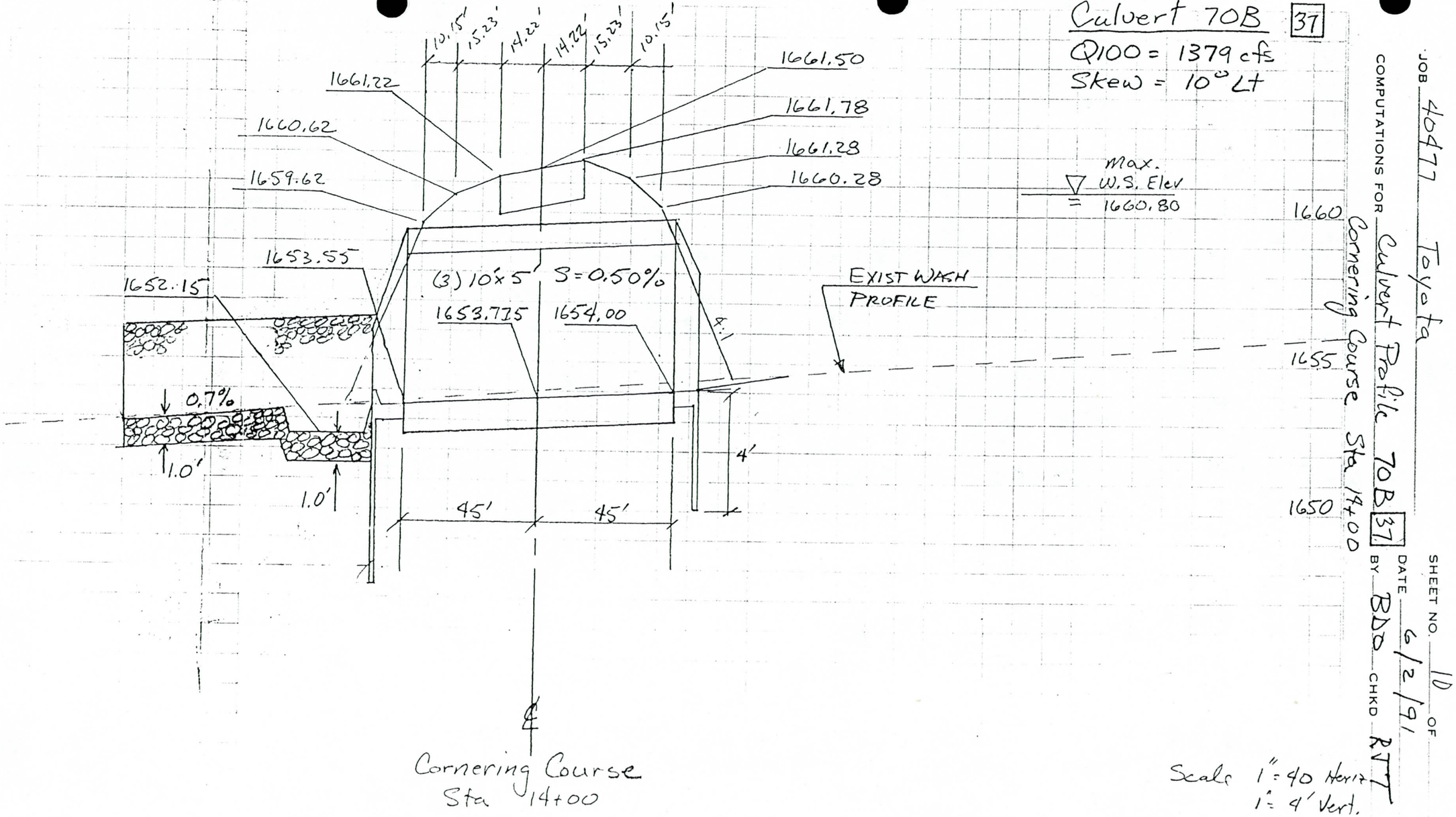
COMPUTATIONS FOR Culvert Profile 70B 37 DATE 6/2/91

Cornering Course Sta 14+00 BY BDO CHKD RJT

Culvert 70B 37

Q100 = 1379 cfs

Skew = 10° Lt



Scale 1" = 40 Horiz
1" = 4' Vert.

SECTION NUMBER TW70B 6/3/91

Channel Slope: 0.0084 ft./ft.

CROSS SECTION DATA:

OFFSET	1	38.7	73.3	77.2	80.3	82	124.2	126.3	127.9	133.1	222.6	286	365
ELEV.	55	54.91	54.94	53.76	53.83	54.67	54.55	52.3	52.28	54.52	54.08	54.6	54
N	N/A	0.035	0.035	0.035	0.035	0.035	0.035	0.035	0.025	0.035	0.035	0.035	0.035

STAGE-DISCHARGE DATA:

STAGE: 52.5												
WET PER.	0.0	0.0	0.0	0.0	0.0	0.0	0.3	1.6	0.6	0.0	0.0	0.0
AREA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.1	0.0	0.0	0.0
HYD.RAD.	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.1	0.0	0.0	0.0
Q	0	0	0	0	0	0	0	1	0	0	0	0

STAGE: 52.75												
WET PER.	0.0	0.0	0.0	0.0	0.0	0.0	0.6	1.6	1.2	0.0	0.0	0.0
AREA	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.7	0.3	0.0	0.0	0.0
HYD.RAD.	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.5	0.2	0.0	0.0	0.0
Q	0	0	0	0	0	0	0	2	0	0	0	0

STAGE: 53												
WET PER.	0.0	0.0	0.0	0.0	0.0	0.0	1.0	1.6	1.8	0.0	0.0	0.0
AREA	0.0	0.0	0.0	0.0	0.0	0.0	0.2	1.1	0.6	0.0	0.0	0.0
HYD.RAD.	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.7	0.3	0.0	0.0	0.0
Q	0	0	0	0	0	0	0	5	1	0	0	0

STAGE: 53.25												
WET PER.	0.0	0.0	0.0	0.0	0.0	0.0	1.3	1.6	2.5	0.0	0.0	0.0
AREA	0.0	0.0	0.0	0.0	0.0	0.0	0.4	1.5	1.1	0.0	0.0	0.0
HYD.RAD.	0.0	0.0	0.0	0.0	0.0	0.0	0.3	1.0	0.4	0.0	0.0	0.0
Q	0	0	0	0	0	0	1	8	2	0	0	0

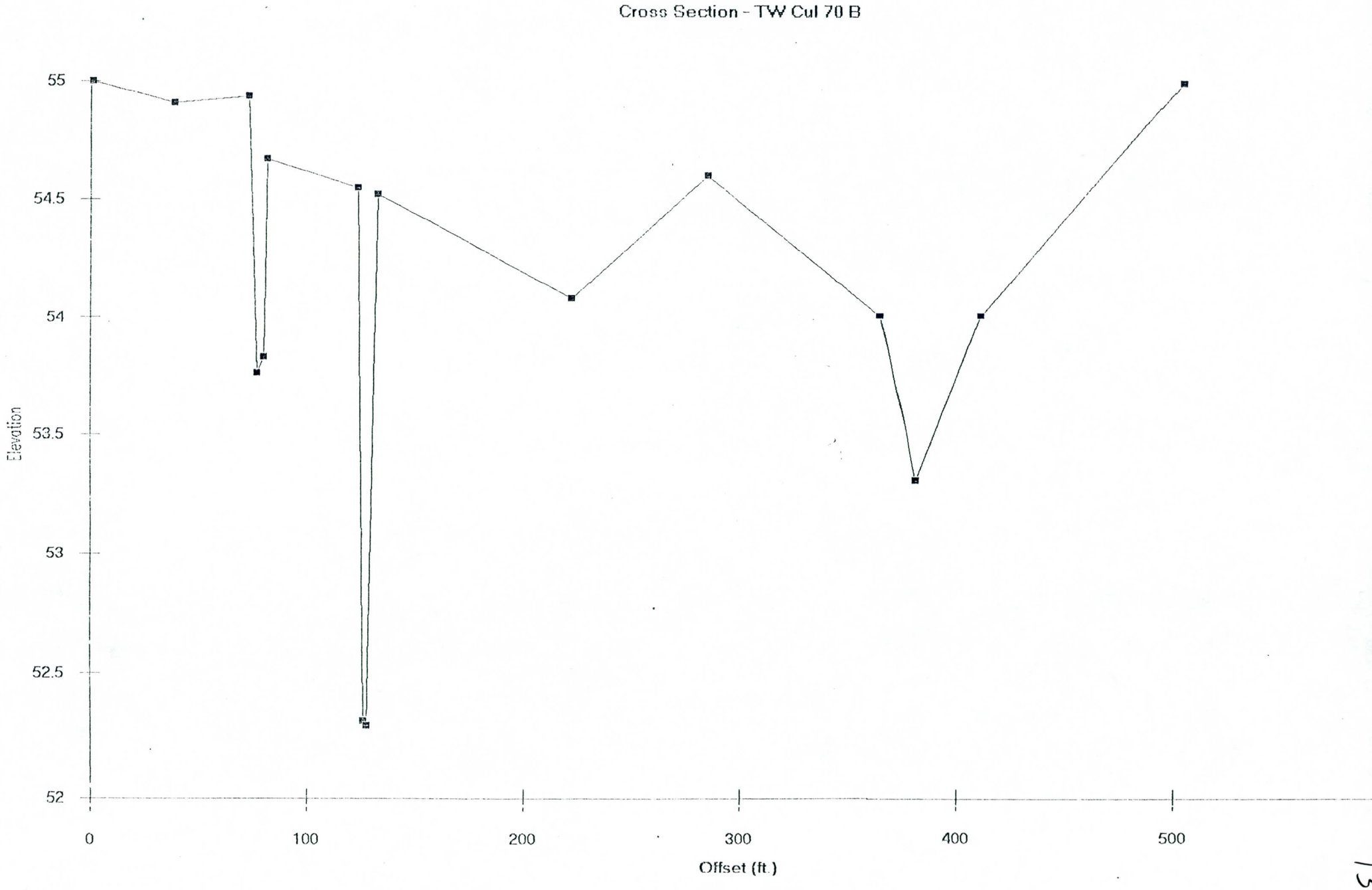
STAGE: 53.5												
WET PER.	0.0	0.0	0.0	0.0	0.0	0.0	1.6	1.6	3.1	0.0	0.0	0.0
AREA	0.0	0.0	0.0	0.0	0.0	0.0	0.7	1.9	1.7	0.0	0.0	0.0
HYD.RAD.	0.0	0.0	0.0	0.0	0.0	0.0	0.4	1.2	0.6	0.0	0.0	0.0
Q	0	0	0	0	0	0	1	12	5	0	0	0

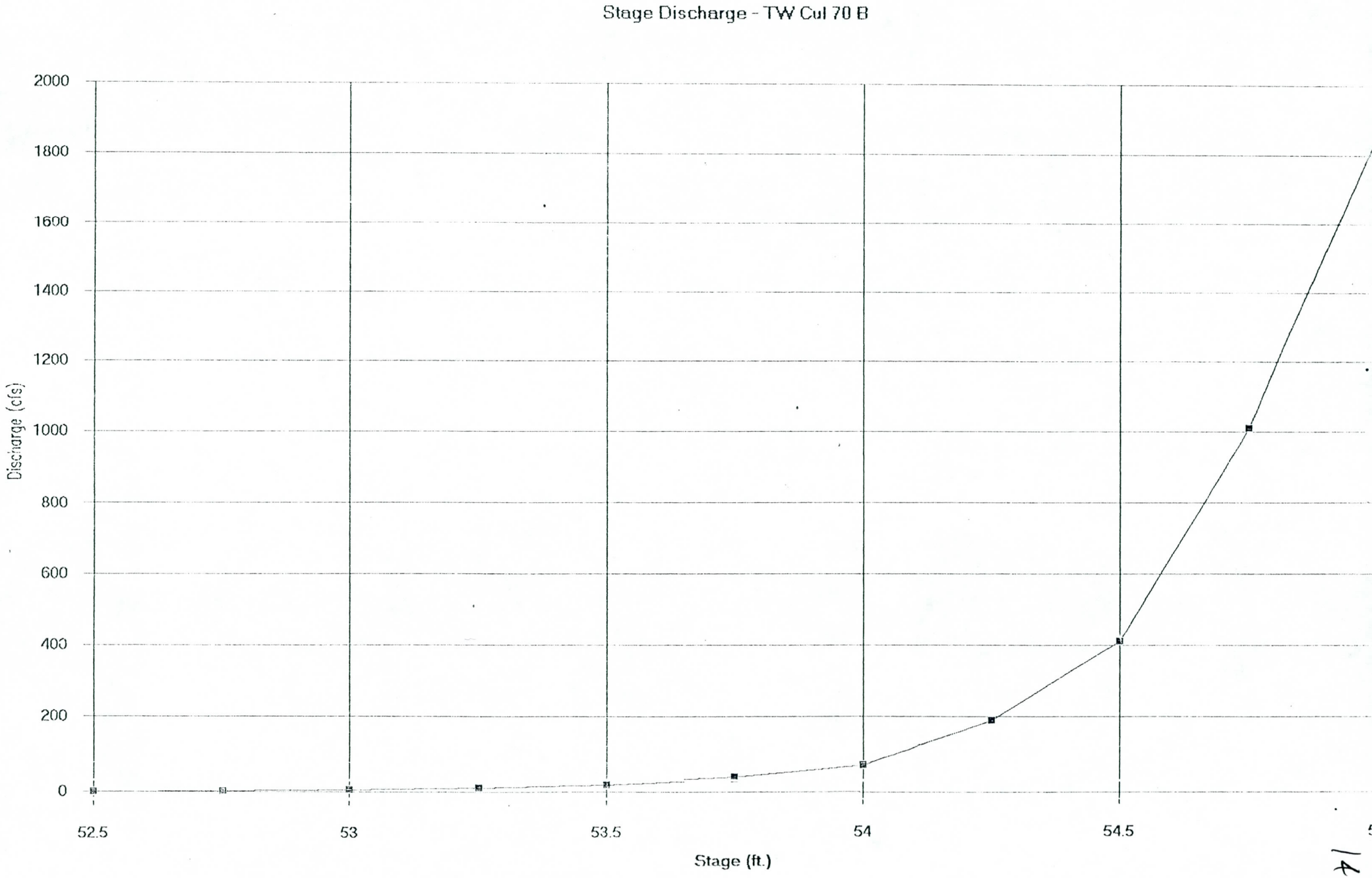
STAGE: 53.75												
WET PER.	0.0	0.0	0.0	0.0	0.0	0.0	2.0	1.6	3.7	0.0	0.0	0.0
AREA	0.0	0.0	0.0	0.0	0.0	0.0	1.0	2.3	2.5	0.0	0.0	0.0
HYD.RAD.	0.0	0.0	0.0	0.0	0.0	0.0	0.5	1.5	0.7	0.0	0.0	0.0
Q	0	0	0	0	0	0	2	16	8	0	0	0

SECTION NUMBER TW70B 6/3/91

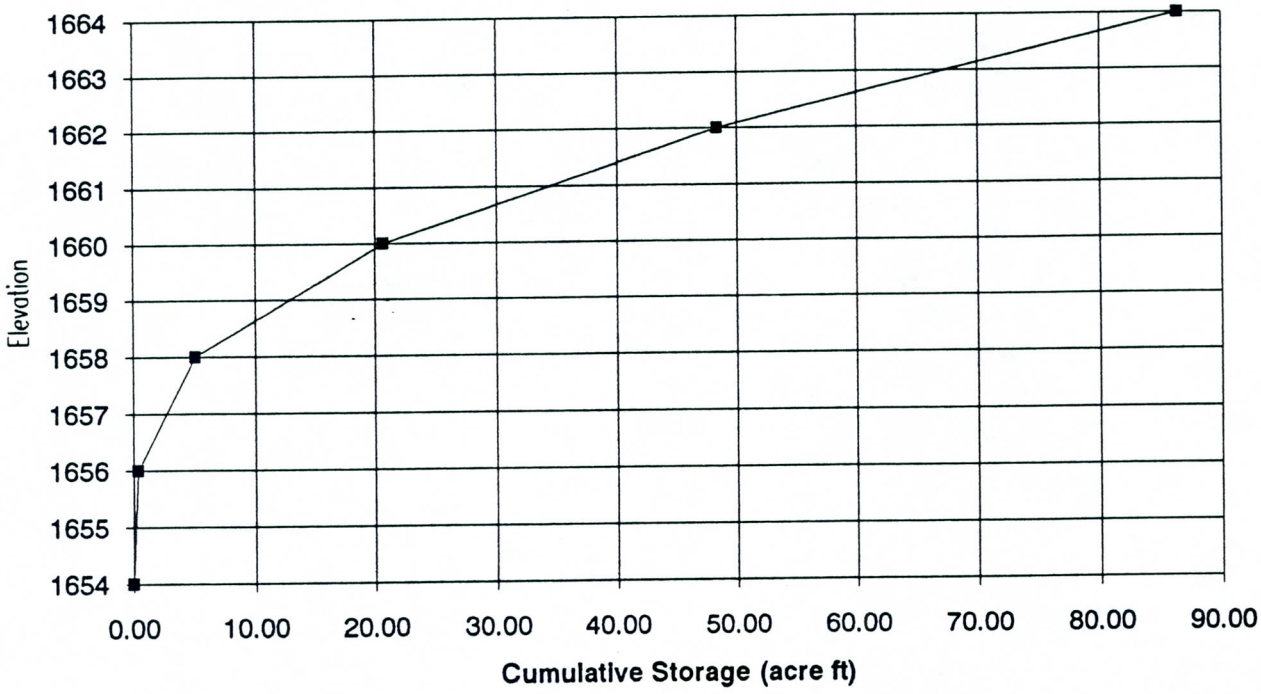
STAGE:	54											
WET PER.		0.0	0.0	0.8	3.9	4.3	0.0	2.3	1.6	4.4	0.0	0.0	0.0
AREA		0.0	0.0	0.1	0.7	0.8	0.0	1.3	2.7	3.4	0.0	0.0	0.0
HYD.RAD.		0.0	0.0	0.1	0.2	0.2	0.0	0.6	1.7	0.8	0.0	0.0	0.0
Q		0	0	0	0	1	0	4	21	11	0	0	0
STAGE:	54.25												
WET PER.		0.0	0.0	1.7	4.8	5.7	0.0	2.7	1.6	5.0	34.6	55.3	32.9
AREA		0.0	0.0	0.4	1.8	2.0	0.0	1.8	3.1	4.5	2.9	4.7	4.1
HYD.RAD.		0.0	0.0	0.2	0.4	0.3	0.0	0.7	2.0	0.9	0.1	0.1	0.1
Q		0	0	0	0	4	0	5	27	16	0	4	0
STAGE:	54.5												
WET PER.		0.0	0.0	2.6	5.7	7.2	0.0	3.0	1.6	5.6	85.4	136.6	65.8
AREA		0.0	0.0	0.9	3.1	3.5	0.0	2.3	3.5	5.7	17.9	28.7	16.5
HYD.RAD.		0.0	0.0	0.4	0.5	0.5	0.0	0.8	2.2	1.0	0.2	0.2	0.2
Q		0	0	0	0	9	0	7	33	23	0	39	0
[illegible]E:	54.75												
[illegible]PER.		0.0	0.0	3.4	6.5	8.4	50.6	53.7	1.6	5.7	95.2	158.6	237.6
[illegible]EA		0.0	0.0	1.6	4.6	5.4	11.3	14.1	3.9	7.0	47.3	73.3	108.8
HYD.RAD.		0.0	0.0	0.5	0.7	0.6	0.2	0.3	2.5	1.2	0.5	0.5	0.5
Q		0	0	0	0	0	0	23	39	0	0	0	0
STAGE:	55												
WET PER.		37.7	72.3	76.4	79.5	81.4	123.6	126.6	1.6	5.7	95.2	158.6	237.6
AREA		1.7	4.3	6.8	10.6	11.8	28.3	31.6	4.3	8.3	71.0	112.8	168.1
HYD.RAD.		0.0	0.1	0.1	0.1	0.1	0.2	0.2	2.7	1.5	0.7	0.7	0.7
Q		0	0	0	0	0	0	49	46	0	0	0	0

W.S. Elev.	52.5	52.75	53	53.25	53.5	53.75	54	54.25	54.5	54.75	55
Q	1	3	6	11	19	36	69	190	411	1009	1859
A	0.4	1.1	2.0	3.0	5.7	12.6	24.7	86.5	179.8	391.4	592.1
V	1.7	2.6	3.2	3.7	3.4	2.9	2.8	2.2	2.3	2.6	3.1


Cross Section - TW Cul 70 B
55
54.5
54
53.5
53
52.5
52
Elevation
0
100
200
300
400
500
Offset (ft.)


Stage Discharge - TW Cul 70 B
2000
1800
1600
1400
1200
1000
800
600
400
200
0
Discharge (cfs)
52.5
53
53.5
54
54.5
Stage (ft.)

Elevation vs. Storage - Node 70 B



SVERDRUP

JOB 404[redacted] Toyota

SHEET NO [redacted]/1 OF _____

DATE 6/3/91

COMPUTATIONS FOR Proposed Culvert 70G [38] Cornering Course

BY BDO CHKD RJT

CULVERT COMPUTATION SHEET

PROJECT: _____

STATION: 1+62

DESIGNER: _____

DATE: _____

HYDROLOGIC AND CHANNEL INFORMATION

DRAINAGE AREA _____

Q_1 = 2259 cfs

Q_2 = _____

TW_1 = 3.0'

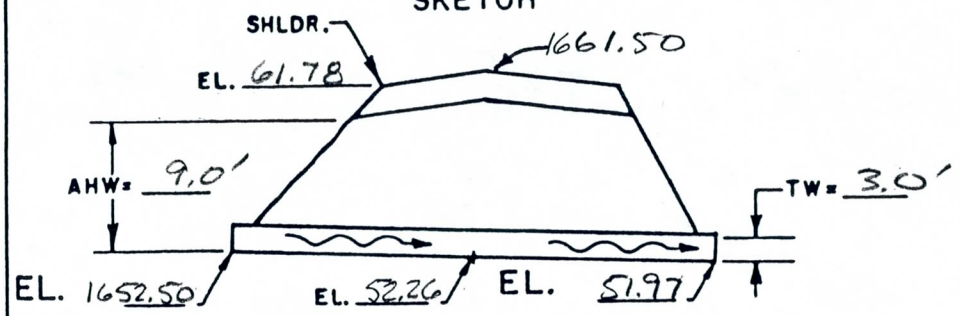
TW_2 = _____

Peak Outlet Discharge

(Q_1 = DESIGN DISCHARGE, SAY Q_{25}) Q100

(Q_2 = CHECK DISCHARGE, SAY Q_{50})

SKETCH



S_0 = .0050'/' L = 106' L/100 S_0 = _____

MEAN STREAM VELOCITY = 3.8 fps

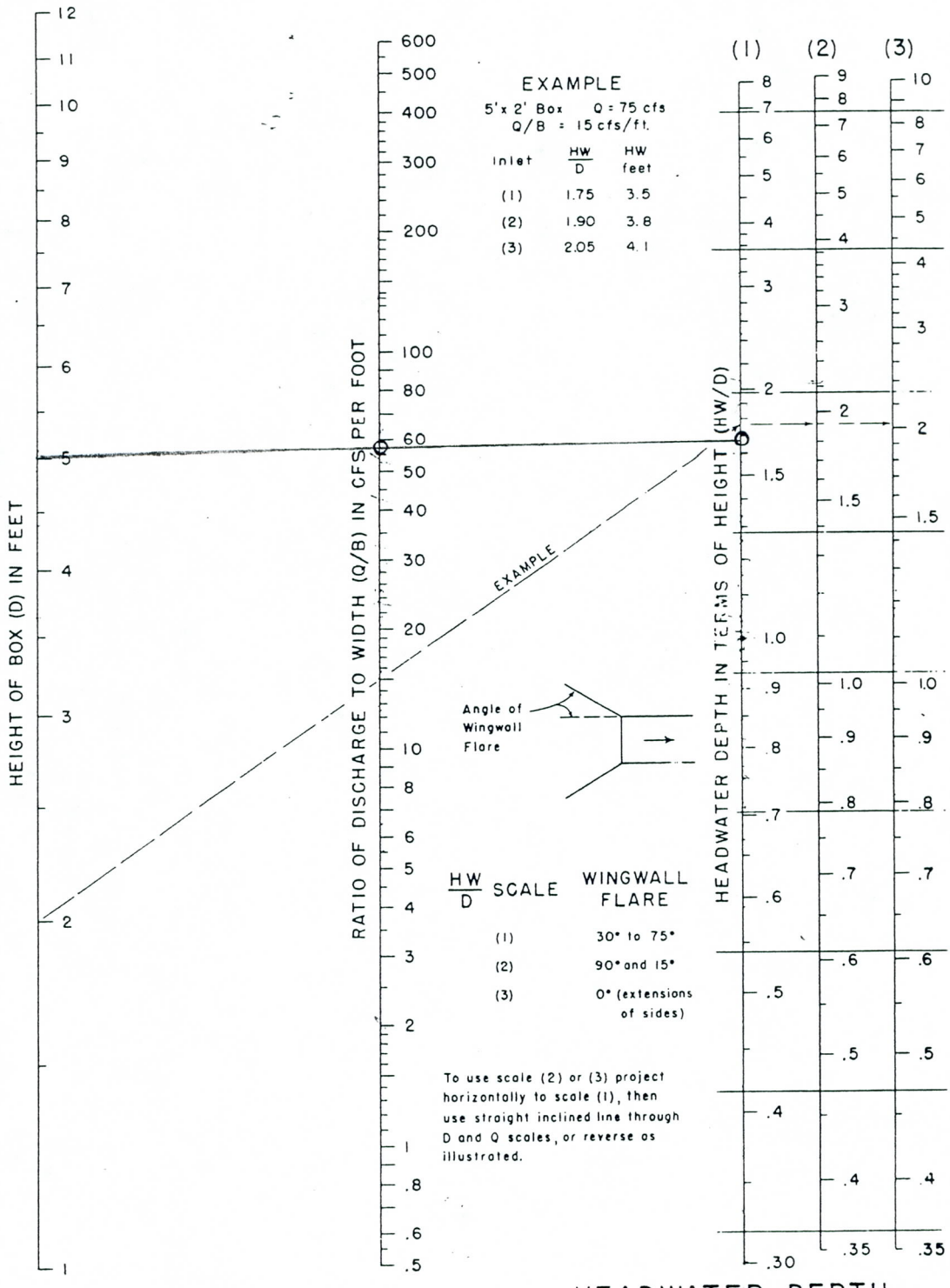
CULVERT DESCRIPTION		Q	CAP. CHART HW	HEADWATER COMPUTATION										CONTROL HW	OUTLET VELOCITY	COST	DHW ELEV.	COMMENTS
				INLET CONT.		OUTLET CONTROL HW = H + h_o − LS_o												
SIZE	ENTR. TYPE			HW/D	HW	K_e	H	d_c	$\frac{d_c + D}{2}$	TW	h_o	LS_o	HW					
(4) Bar. 10x5	Headwalls 20° Skew	2259/4 565		1.68	8.40	0.20	2.95	4.70	4.85	3.0	4.85	0.53	7.27	8.40	14.7		1660.90	Inlet Control

SUMMARY & RECOMMENDATIONS Use riprap plunge basin for erosion control. Design for Q10 flow.

B-10

Culvert 70 G

CHART 1

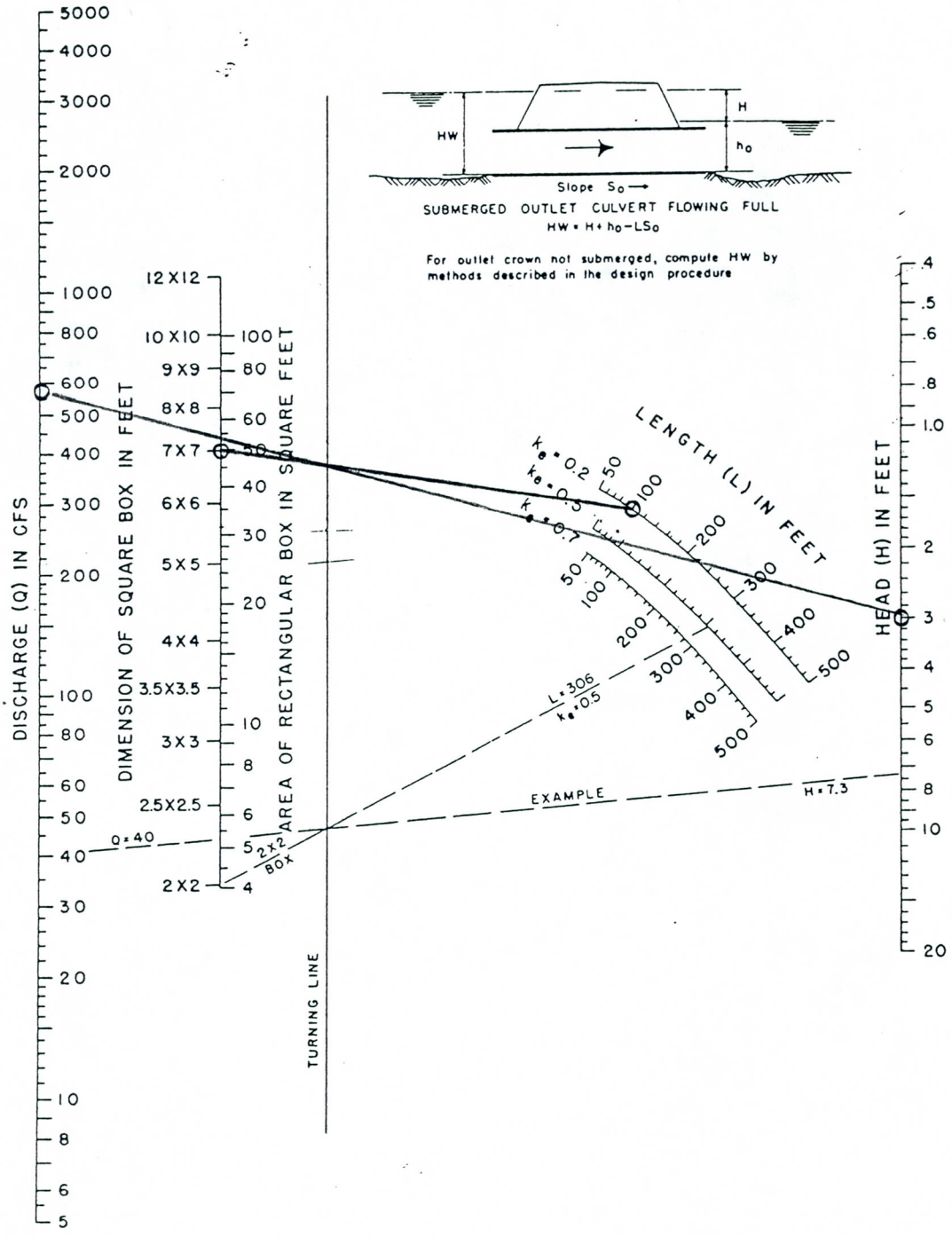


HEADWATER DEPTH FOR BOX CULVERTS WITH INLET CONTROL

BUREAU OF PUBLIC ROADS JAN. 1963

Culvert 70 G

CHART 8



2.95'

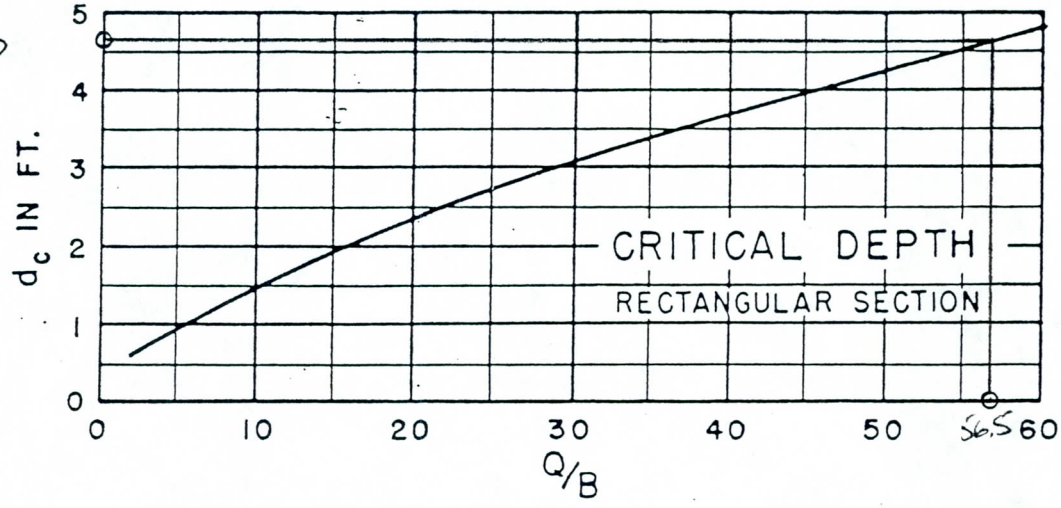
HEAD FOR CONCRETE BOX CULVERTS FLOWING FULL n = 0.012

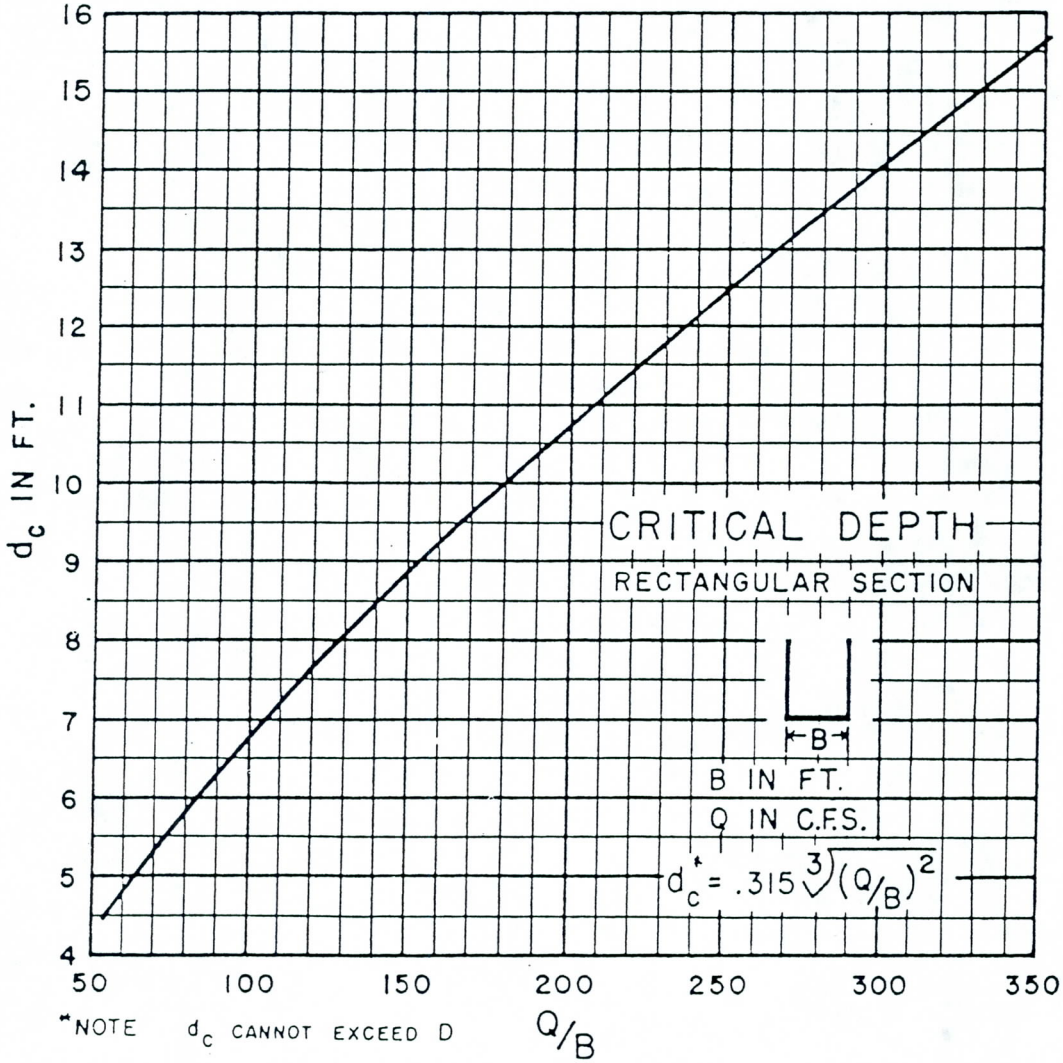
BUREAU OF PUBLIC ROADS JAN. 1963

Culvert 70 G

CHART 15

4.70





*NOTE d_c CANNOT EXCEED D

BUREAU OF PUBLIC ROADS JAN 1963

SVERDRUP

JOB 40477 Toyota SHEET NO. 5 OF

COMPUTATIONS FOR Box Culvert 70G DATE 6/4/91 BY BDO CHKD RJT

Check depth of flow using Mannings Equation

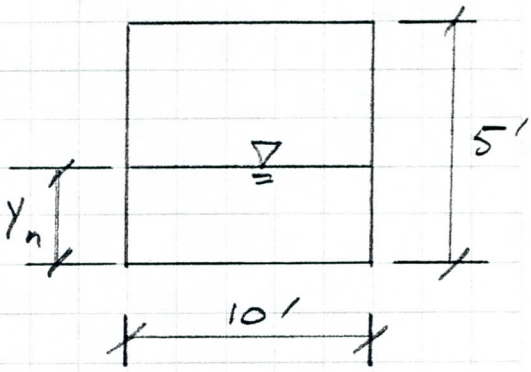
$Q_{100} = 2259$ cfs

$Q/barrel = 565$ cfs

$n = .012$

$S_o = 0.0050$ ft/ft

$Y_n \sim 3.85'$



$A = 38.5$ ft^2

$WP = 17.70$ ft

$R_h = A/WP = \frac{38.5}{17.7} = 2.1751$ ft

$V = \frac{1.49}{.012}(2.1751)^{.666}(.005)^{1/2} = 14.73$ fps

$Q = VA = 14.73(38.5) = 567$ cfs (OK)

Check Froude Number

$F = \frac{V}{\sqrt{g Y_c}} = \frac{14.73}{\sqrt{32.2(3.85)}} = 1.32$ Supercritical

Channel needs protection Use Grouted Riprap plunge Basin, $F < 3.0$ (OK)

$Q_{10} = 851$ cfs $\Rightarrow$ 213 cfs/barrel

$Y_n = 1.94'$ Vel. = 10.96 fps, $F = 1.39$, Supercritical

SVERDRUP

JOB 40477 Toyota

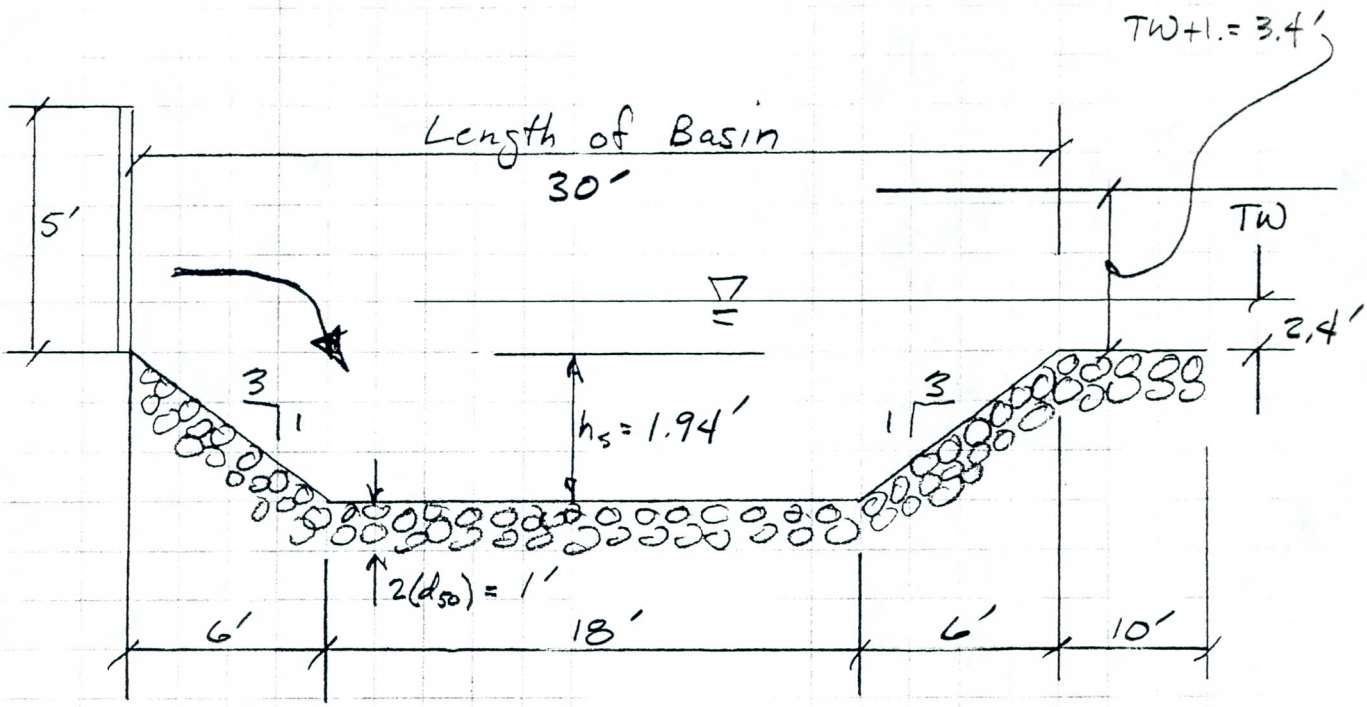
COMPUTATIONS FOR Box Culvert 70 G

SHEET NO. 6 OF

DATE 6/29/91

BY BDO CHKD RJT

Riprap Plunge Basin Design



Check Rock Size (From Figure XI-2, HEC No 14)

For Y_o = 1.94' d_{50} = 6" or 0.50'

$d_{50}/Y_o = \frac{0.50'}{1.94'} = 0.26$, $F = 1.39$

$\frac{h_s}{Y_o} = 1.00$ $h_s = 1.00\,(1.94') = 1.94'$

Check $\frac{h_s}{d_{50}} = \frac{1.94'}{0.50'} = 3.88 < 4$ but > 2 ∴ OK

Length of Basin

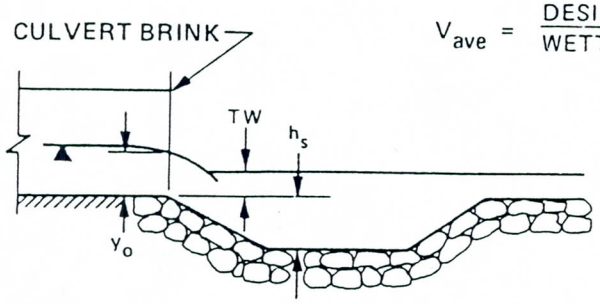
$10\,h_s = 10'(1.94) = 19.4'$

or

$3(w_o) = 3(10') = 30'$

Use 30'

Culvert 70 G



$$V_{ave} = \frac{\text{DESIGN DISCHARGE} - Q}{\text{WETTED AREA AT BRINK OF CULVERT}}$$

d_{50} = THE MEDIAN SIZE OF ROCK BY WEIGHT. ROUNDED ROCK OR ANGULAR ROCK.

Y_e = EQUIVALENT BRINK DEPTH

= BRINK DEPTH FOR BOX CULVERT

$= \left(\frac{A}{2}\right)^{1/2}$ FOR NON–RECTANGULAR SECTIONS

℄ SECTION

NOTE: $2 \leq \frac{h_s}{d_{50}} \leq 4$

IF $\frac{T_W}{Y_o} > 0.75$

RIPRAP MAY BE REQUIRED ON BANKS AND CHANNEL BOTTOM DOWNSTREAM FROM BASIN – SEE DESIGN EXAMPLE IN TEXT.

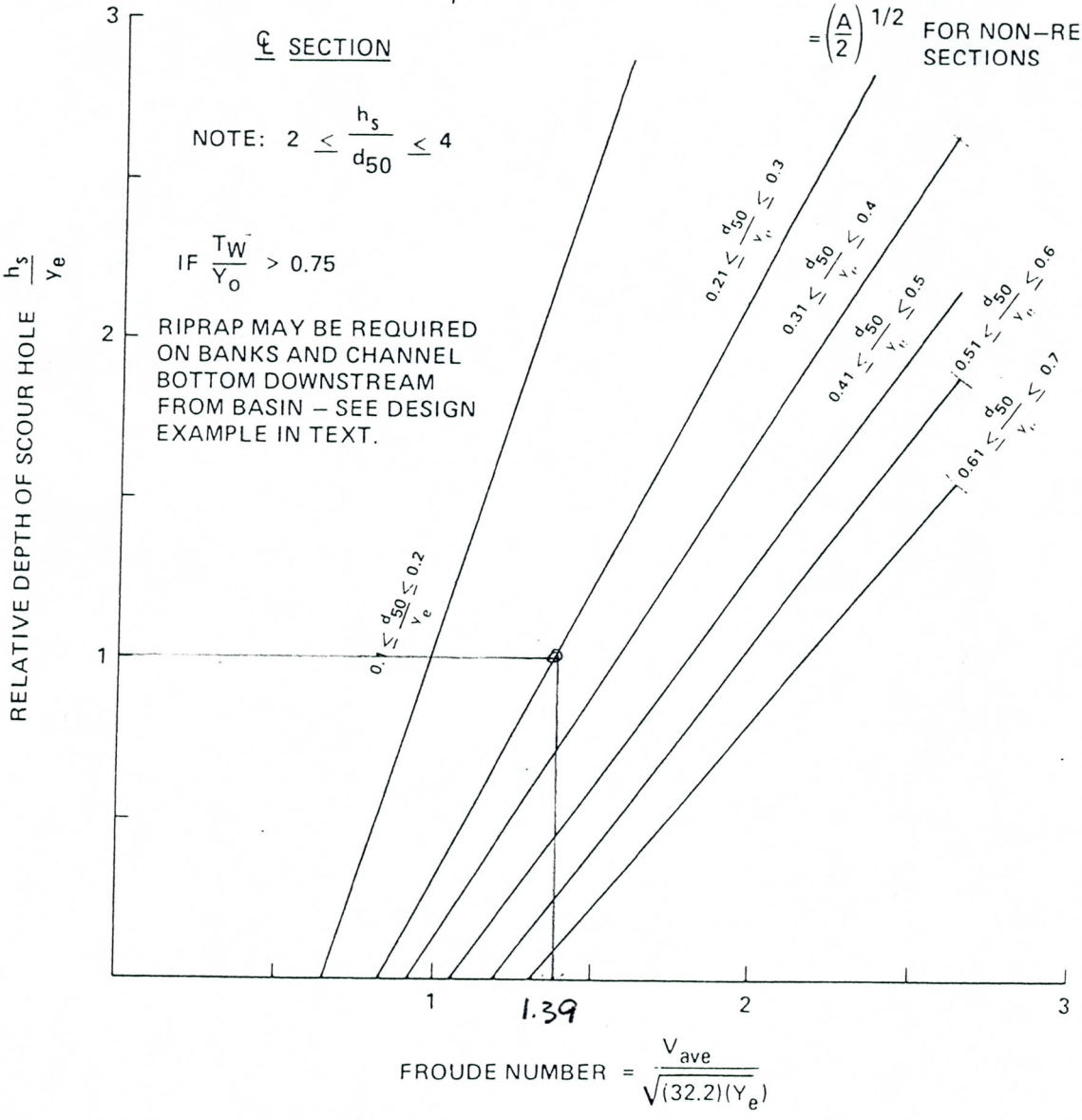


FIGURE X1–2. RELATIVE DEPTH OF SCOUR HOLE VERSUS FROUDE NUMBER AT BRINK OF CULVERT WITH RELATIVE SIZE OF RIPRAP AS A THIRD VARIABLE

$TW/Y_o = \frac{2.4'}{1.94'} = 1.24 > 0.75$ ∴ Check downstream riprap lining for channel protection.

Utilize figure XI-3 for existing average velocity along channel. Compute equivalent circular diameter D_e for brink area from:

$A = \pi D_e^2/4 = Y_o(W_o) = 1.94(10) = 19.4\ ft^2$

$D_e = (19.4(4)/\pi)^{1/2} = 4.97'$

From downstream cross section Q10 velocity is 3.0 fps. Culvert outlet velocity is 10.96 fps.

L/D_e	L	V_L/V_o	V_L
10	49.7'	.59	6.5
15	74.6'	.36	4.0
20	99.4'	.30	3.3 ~ 3.0 fps OK

∴ Need riprap lining for approximately 100 feet from the end of the culvert outlet apron.

SVERDRUP

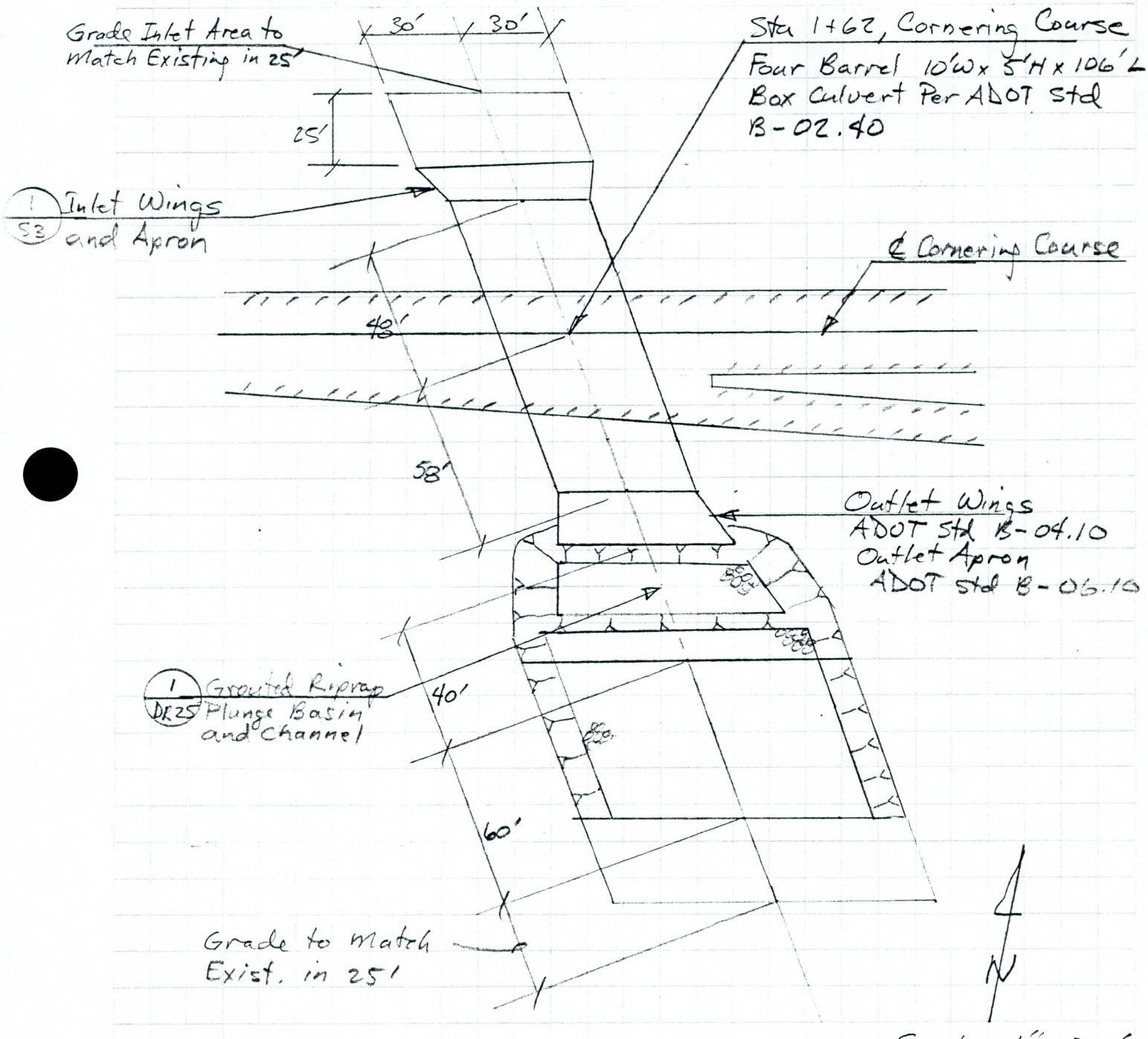
JOB 40477 Toyota

COMPUTATIONS FOR Box Culvert 70 G [38]

SHEET NO. 9 OF

DATE 6/22/91

BY BDO CHKD RJT



Plan View
Culvert 70G

SVERDRUP

JOB 40477 Toyota SHEET NO. 10 OF

COMPUTATIONS FOR Culvert Profile 70G 38 DATE 6/11/91

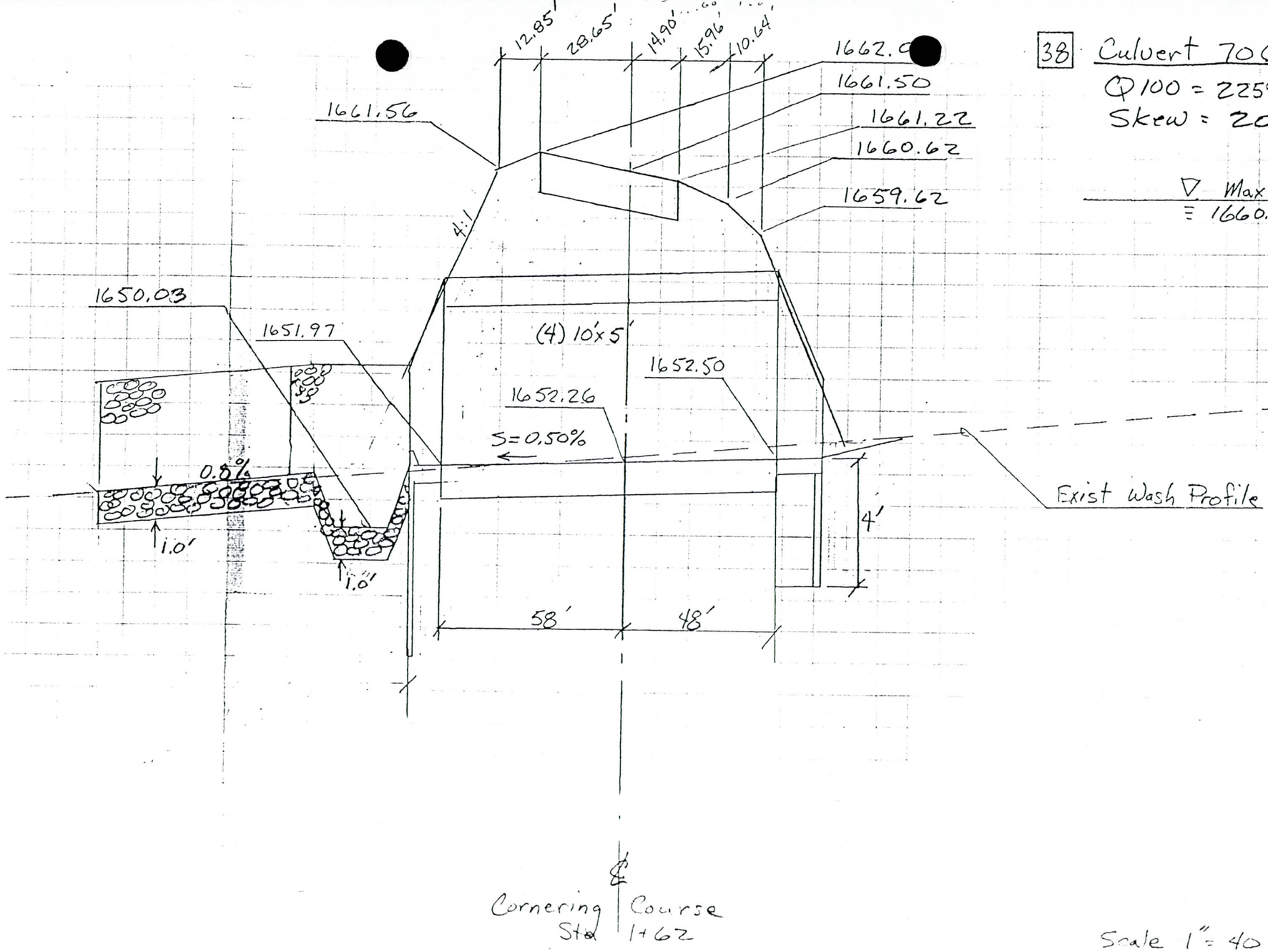
Cornering Course Sta 1+62 BY BDO CHKD RJT

38 Culvert 70G

Q100 = 2259 cfs

Skew = 20° Lt

▽ Max W.S. = 1660.90



Scale 1" = 40' Horiz

1" = 4' Vert

SECTION NUMBER TW70G 6/22/91

Channel Slope: 0.0059 ft./ft.

CROSS SECTION DATA:

OFFSET	40	78	190	245	252	260	351.1	382.7	386.1	391.4	393.5	413	415.9	422.5	424.6
ELEV.	54.5	54	52.9	52	51.8	52	53.17	52.9	51.57	51.35	52.9	52.48	50.91	50.83	52.54
N	N/A	0.035	0.035	0.035	0.025	0.025	0.035	0.035	0.035	0.025	0.035	0.035	0.035	0.025	0.035

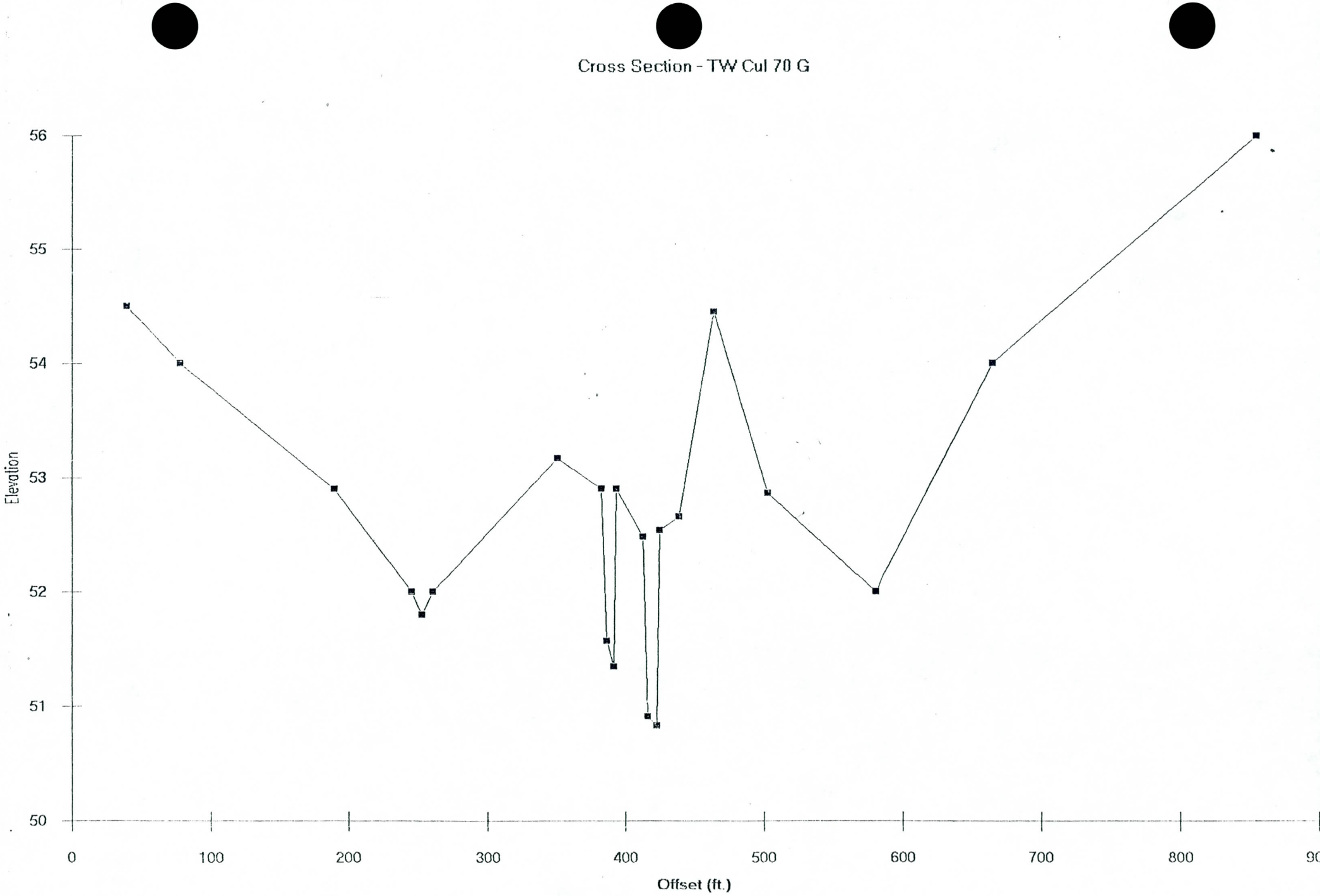
STAGE-DISCHARGE DATA:

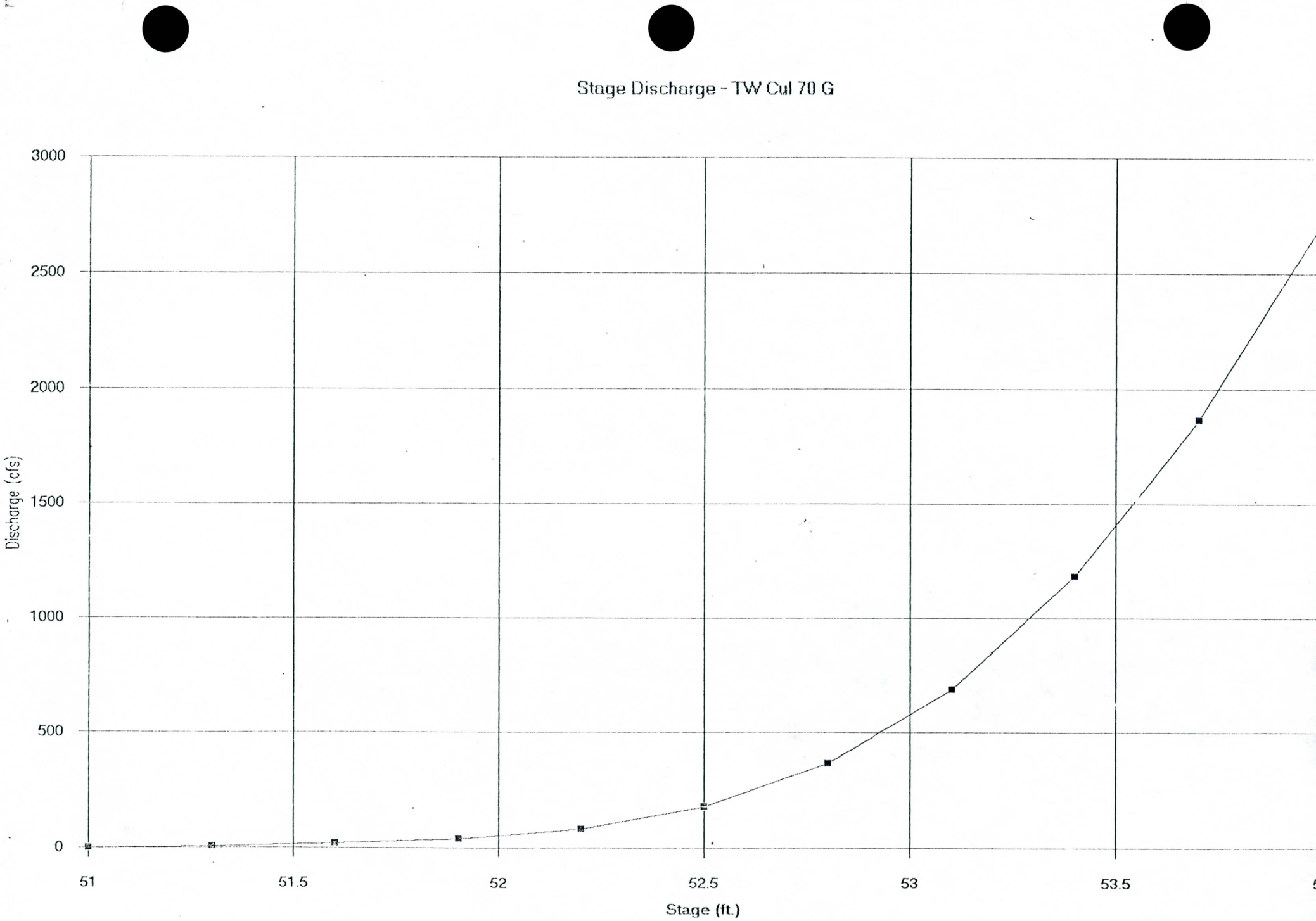
STAGE:	51													
WET PER.		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	6.6	0.3
AREA		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.9	0.0
HYD.RAD.		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1
Q		0	0	0	0	0	0	0	0	0	0	0	0	1	0
STAGE:	51.3														
WET PER.		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8	6.6	0.7
AREA		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	2.8	0.1
HYD.RAD.		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.4	0.2
Q		0	0	0	0	0	0	0	0	0	0	0	0	7	0
STAGE:	51.6														
WET PER.		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	5.3	0.4	0.0	1.5	6.6	1.2
AREA		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.0	0.0	0.4	4.8	0.4
HYD.RAD.		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.3	0.7	0.3
Q		0	0	0	0	0	0	0	0	1	0	0	1	18	1
STAGE:	51.9														
WET PER.		0.0	0.0	0.0	3.5	7.5	0.0	0.0	0.9	5.3	0.9	0.0	2.1	6.6	1.7
AREA		0.0	0.0	0.0	0.2	0.4	0.0	0.0	0.1	2.3	0.2	0.0	0.9	6.8	0.7
HYD.RAD.		0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.2	0.4	0.2	0.0	0.4	1.0	0.4
Q		0	0	0	0	0	0	0	0	6	0	0	2	32	1
STAGE:	52.2														
WET PER.		0.0	0.0	12.2	7.0	15.0	15.6	0.0	1.7	5.3	1.4	0.0	2.7	6.6	2.2
AREA		0.0	0.0	1.2	2.1	4.5	1.6	0.0	0.5	3.9	0.5	0.0	1.5	8.8	1.2
HYD.RAD.		0.0	0.0	0.1	0.3	0.3	0.1	0.0	0.3	0.7	0.3	0.0	0.6	1.3	0.5
Q		0	0	1	0	9	1	0	1	15	1	0	3	48	2
STAGE:	52.5														
WET PER.		0.0	0.0	30.6	7.0	15.0	38.9	0.0	2.6	5.3	1.9	0.9	4.2	6.6	2.6
AREA		0.0	0.0	7.6	4.2	9.0	9.7	0.0	1.1	5.5	0.9	0.0	2.3	10.8	1.7
HYD.RAD.		0.0	0.0	0.2	0.6	0.6	0.3	0.0	0.4	1.0	0.5	0.0	0.6	1.6	0.6
Q		0	0	10	0	29	13	0	2	26	2	0	5	68	4

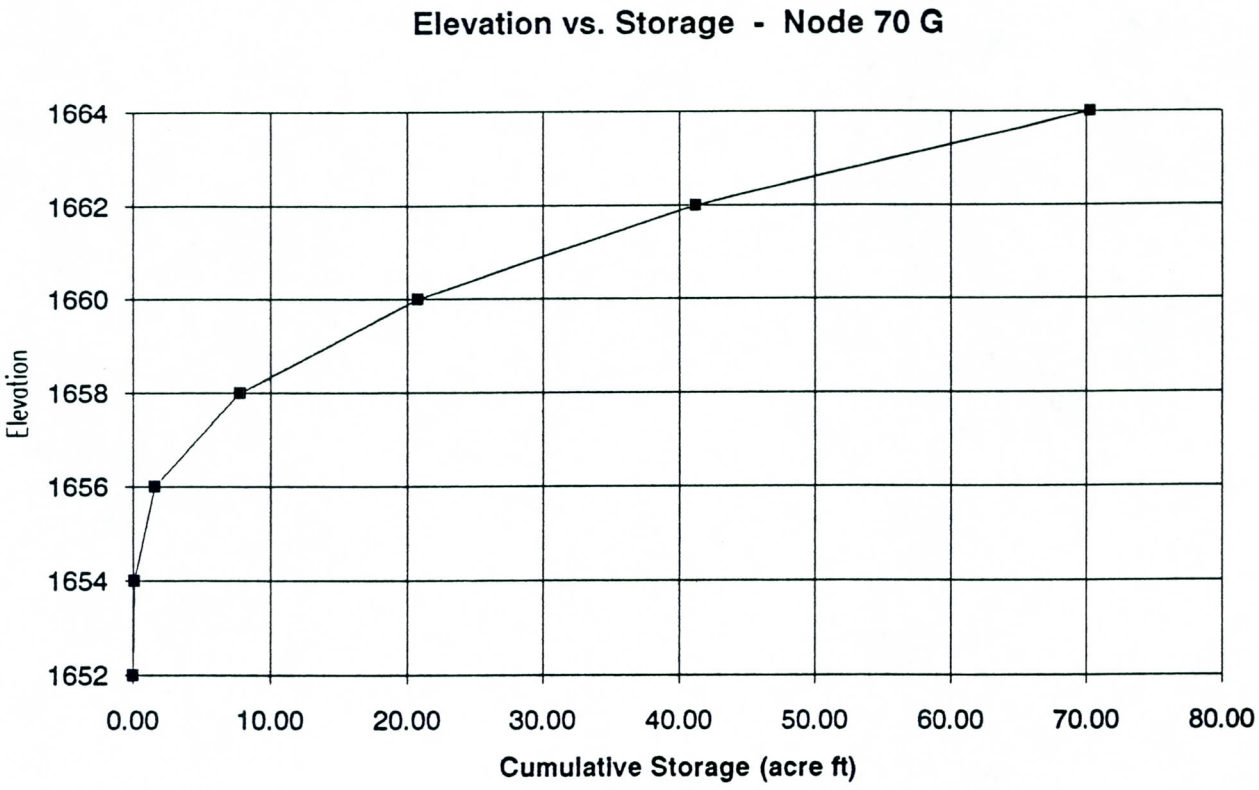
SECTION NUMBER TW70G 6/22/91

STAGE:	52.8													
WET PER.		0.0	0.0	48.9	7.0	15.0	62.3	0.0	3.4	5.3	2.4	14.9	18.2	6.6	2.7
AREA		0.0	0.0	19.6	6.3	13.5	24.9	0.0	1.9	7.1	1.4	2.4	5.6	12.7	2.3
HYD.RAD.		0.0	0.0	0.4	0.9	0.9	0.4	0.0	0.6	1.3	0.6	0.2	0.3	1.9	0.9
Q		0	0	35	0	57	44	0	4	39	3	0	8	90	0
STAGE:	53.1														
WET PER.		0.0	20.4	75.4	7.0	15.0	85.7	23.4	27.1	5.3	2.6	22.1	25.4	6.6	2.7
AREA		0.0	2.0	37.8	8.4	18.0	47.1	2.3	5.3	8.7	2.0	10.0	14.1	14.7	3.0
HYD.RAD.		0.0	0.1	0.5	1.2	1.2	0.5	0.1	0.2	1.6	0.8	0.5	0.6	2.2	1.1
Q		0	0	78	0	93	103	0	6	55	0	0	31	115	0
STAGE:	53.4														
WET PER.		0.0	50.9	105.9	7.0	15.0	91.1	122.7	126.4	5.3	2.6	22.1	25.4	6.6	2.7
AREA		0.0	12.7	65.0	10.5	22.5	74.2	85.8	89.7	10.3	2.7	16.5	21.5	16.7	3.6
HYD.RAD.		0.0	0.2	0.6	1.5	1.5	0.8	0.7	0.7	1.9	1.0	0.7	0.8	2.5	1.3
Q		0	0	153	0	135	0	0	233	73	0	0	63	142	0
STAGE:	53.7														
WET PER.		0.0	81.5	136.5	7.0	15.0	91.1	122.7	126.4	5.3	2.6	22.1	25.4	6.6	2.7
AREA		0.0	32.6	101.3	12.6	27.0	101.6	122.6	127.6	11.9	3.3	23.0	28.8	18.7	4.2
HYD.RAD.		0.0	0.4	0.7	1.8	1.8	1.1	1.0	1.0	2.2	1.3	1.0	1.1	2.8	1.6
Q		0	0	271	0	182	0	0	419	93	0	0	102	171	0
STAGE:	54														
WET PER.		0.0	112.0	167.0	7.0	15.0	91.1	122.7	126.4	5.3	2.6	22.1	25.4	6.6	2.7
AREA		0.0	61.6	146.9	14.7	31.5	128.9	159.4	165.4	13.5	3.9	29.5	36.2	20.7	4.9
HYD.RAD.		0.0	0.5	0.9	2.1	2.1	1.4	1.3	1.3	2.5	1.5	1.3	1.4	3.1	1.8
Q		0	0	440	0	236	0	0	645	114	0	0	149	202	0

W.S. Elev.	51	51.3	51.6	51.9	52.2	52.5	52.8	53.1	53.4	53.7	54
Q	1	8	20	41	84	180	364	686	1184	1865	2717
A	0.9	3.1	6.4	11.5	26.3	65.3	134.5	235.5	364.9	511.2	673.9
V	1.2	2.5	3.1	3.6	3.2	2.8	2.7	2.9	3.2	3.6	4.0


Cross Section - TW Cul 70 G
56
55
54
53
52
51
50
Elevation
0
100
200
300
400
500
600
700
800
Offset (ft.)


Stage Discharge - TW Cul 70 G
3000
2500
2000
1500
1000
500
0
Discharge (cfs)
51
51.5
52
52.5
53
53.5
Stage (ft.)


Elevation vs. Storage - Node 70 G
1664
1662
1660
1658
1656
1654
1652
Elevation
0.00
10.00
20.00
30.00
40.00
50.00
60.00
70.00
80.00
Cumulative Storage (acre ft)

JOB 40 Toyota

COMPUTATIONS FOR Culvert 76 E [39]

SHEET NO 1 OF

DATE 3/91

BY BDO CHKD RJT

CULVERT COMPUTATION SHEET

PROJECT:

STATION: 18+70, Access Road A-1A

DESIGNER:

DATE:

HYDROLOGIC AND CHANNEL INFORMATION

DRAINAGE AREA 0.40 Sq. Miles

Q_1 = 817 cfs

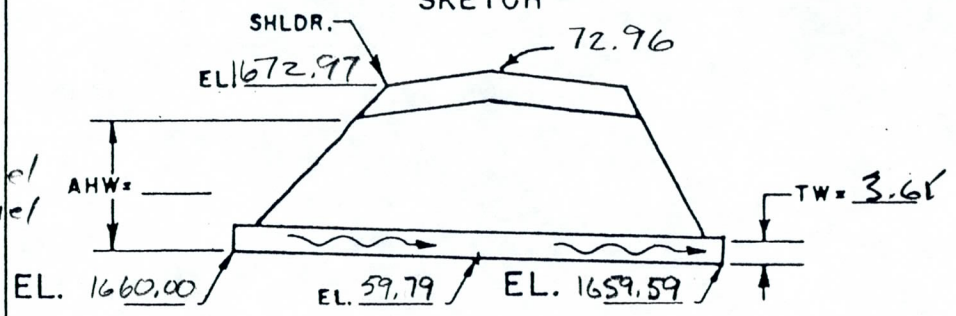
Q_2 =

TW_1 = 4.6' Exist. Channel

TW_2 = 3.61' New Channel

(Q_1 = DESIGN DISCHARGE, SAY ~~Q_{25}~~ Q_{100}; Q_2 = CHECK DISCHARGE, SAY Q_{50})

SKETCH



S_0 = 0.0050 ft/ft L = 82' L/100 S_0 =

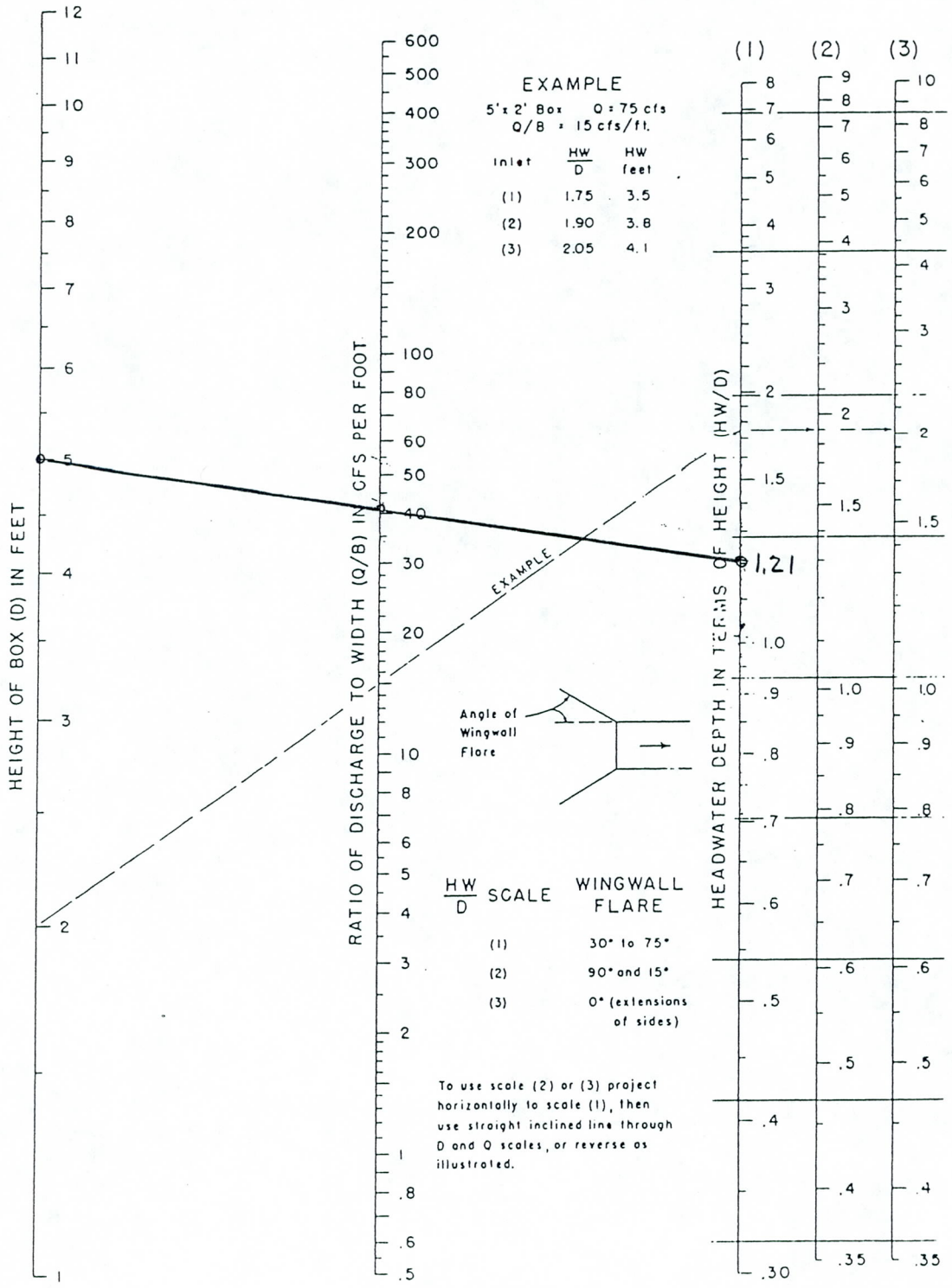
MEAN STREAM VELOCITY = 6.0 fps

CULVERT DESCRIPTION SIZE	CULVERT DESCRIPTION ENTR. TYPE	Q	CAP. CHART HW	HEADWATER COMPUTATION: INLET CONT. HW/D	INLET CONT. HW	OUTLET CONTROL HW = H + h_o − LS_o: K_e	H	d_c	$\frac{d_c + D}{2}$	TW	H_o	LS_o	HW	CONTROL HW	OUTLET VELOCITY	COST	DHW ELEV.	COMMENTS
(2) Barrel 10'x5'	Headwall	817/2 = 409		1.21	6.05	0.2	1.40	3.75	4.38	3.61	4.38'	0.41	5.37	6.05	13.4		1666.05	Inlet Control

SUMMARY & RECOMMENDATIONS Use grouted plunge basin and rock lined channel downstream

Culvert 76 E

CHART 1



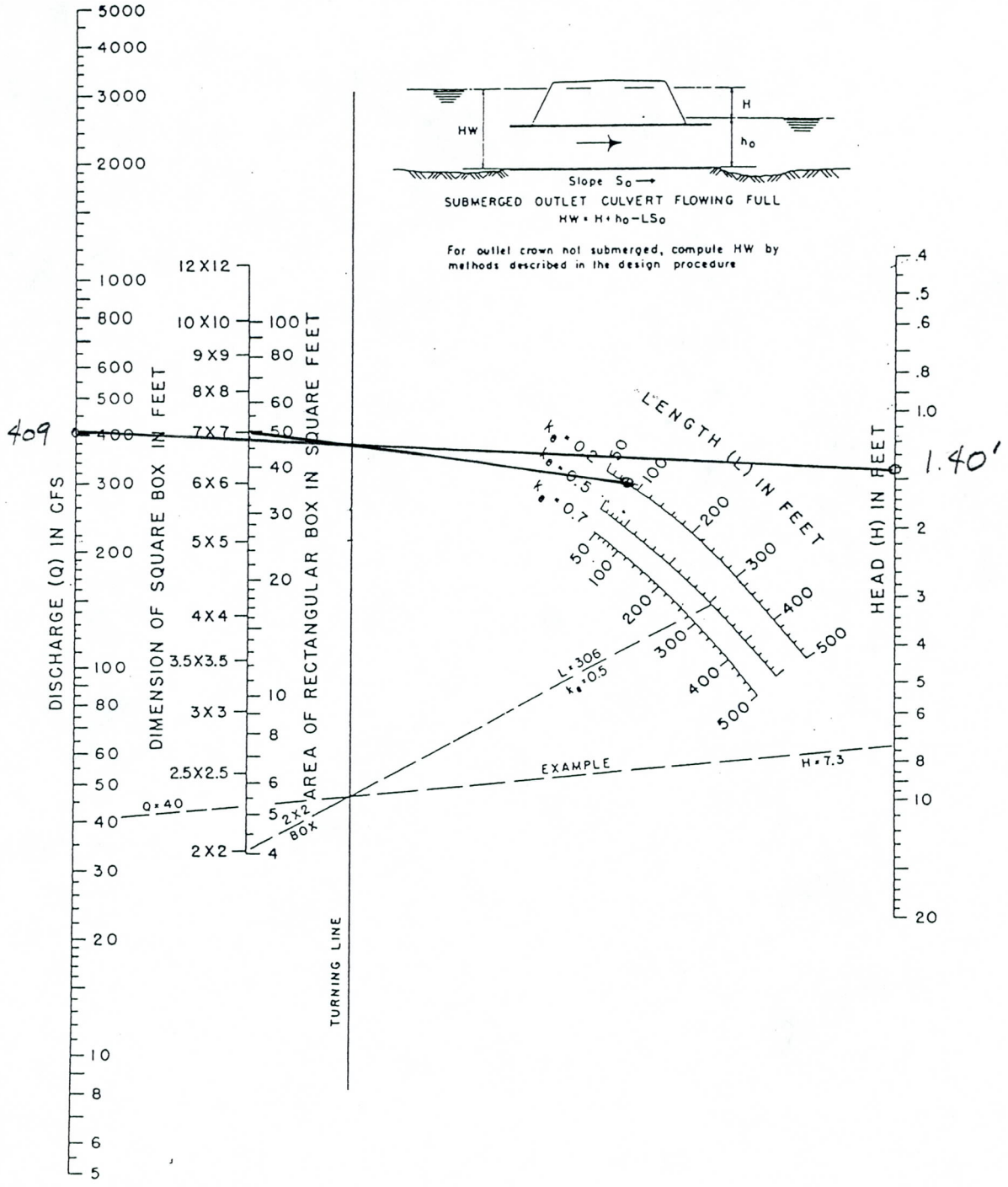
HEADWATER DEPTH FOR BOX CULVERTS WITH INLET CONTROL

BUREAU OF PUBLIC ROADS JAN. 1963

Culvert 76 E

3

CHART 8

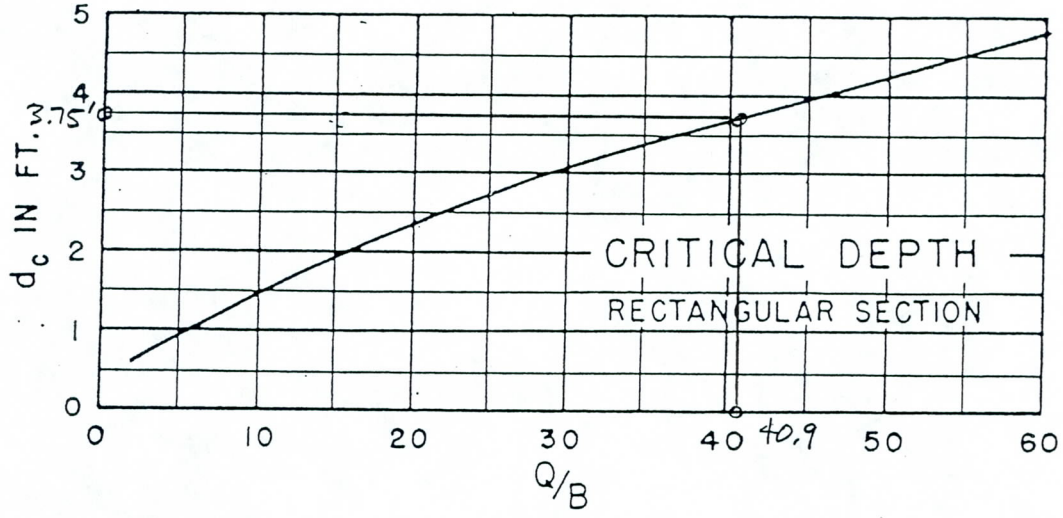


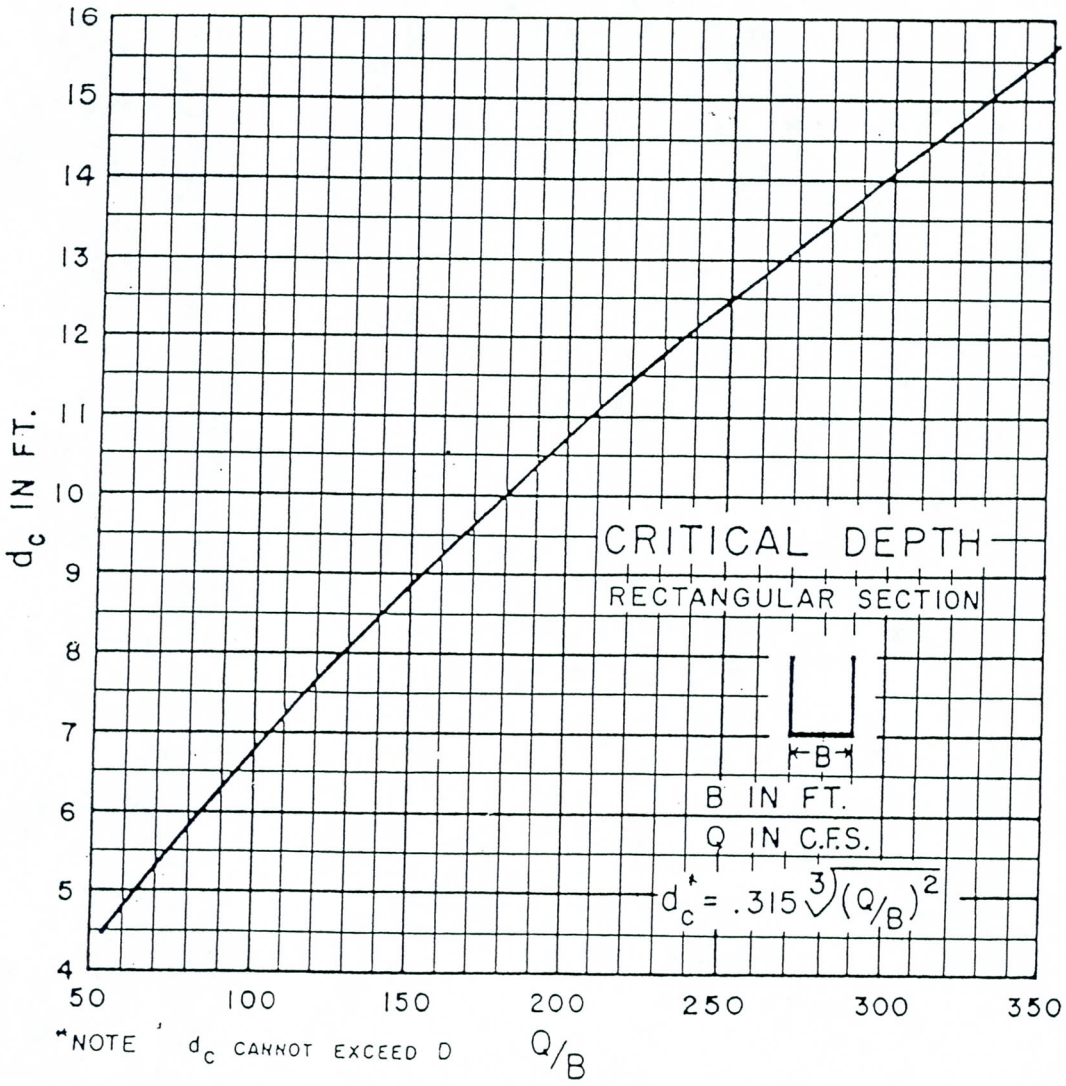
HEAD FOR
CONCRETE BOX CULVERTS
FLOWING FULL
n = 0.012

BUREAU OF PUBLIC ROADS JAN. 1963

Culvert 76 E

CHART 15





*NOTE d_c CANNOT EXCEED D

BUREAU OF PUBLIC ROADS JAN 1963

SVERDRUP

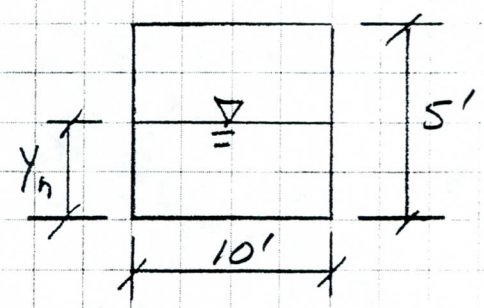
JOB 40477 Toyota SHEET NO. 5 OF

COMPUTATIONS FOR Culvert 76E DATE 7/18/91

BY BDO CHKD RJT

Check depth of Flow using Manning Eqn.

$Q100 = 817$ cfs, $Q/barrel = 409$ cfs



$n = 0.012$

$S_o = 0.0050$ ft/ft

$Y_n \sim 3.05'$

$A = 30.5$ ft^2

$WP = 2(3.05) + 10 = 16.10'$

$R_h = A/WP = 30.5/16.10 = 1.8944$

$V = \frac{1.49}{.012}(1.8944)^{.666}(.005)^{.5} = 13.44$ fps

Check

$Q = VA = 13.44(30.50) = 410$ cfs (OK)

Check Froude Number

$F = \frac{V}{\sqrt{g \times Y_n}} = \frac{13.44}{\sqrt{32.2 \times 3.05}} = 1.36$, Supercritical

$Q10 = 371$ cfs $Q/barrel = 185$ cfs

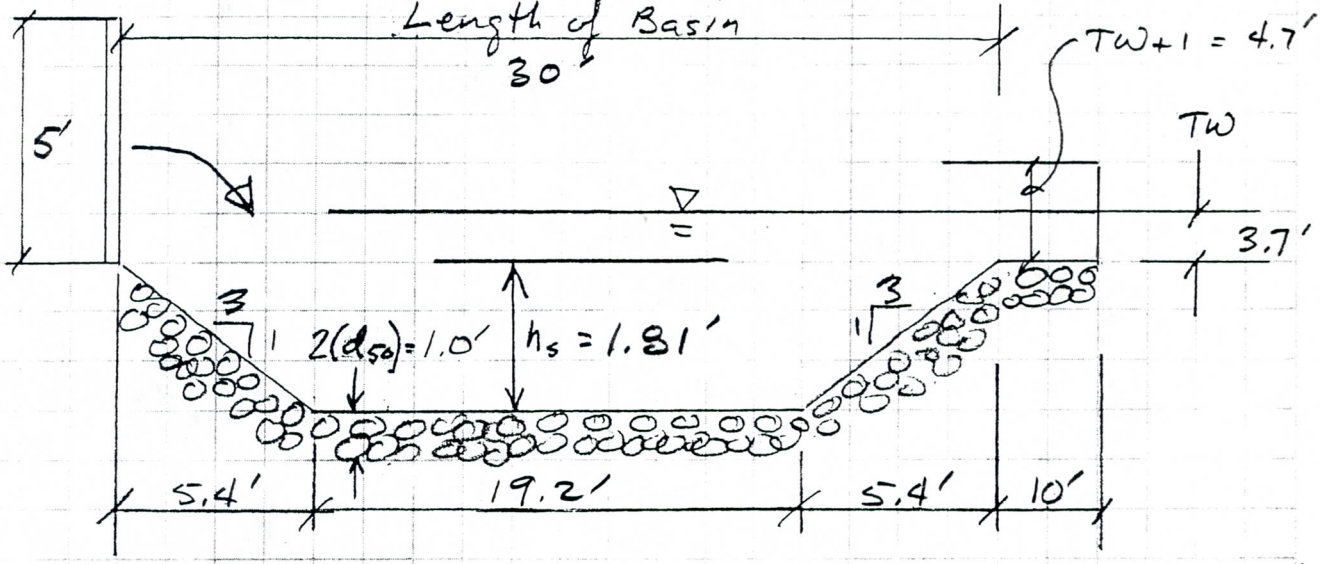
$Y_n = 1.77'$, Velocity $= 10.47$ fps, $F = 1.39$

SVERDRUP

JOB 40477 Toyota SHEET NO. 6 OF

COMPUTATIONS FOR Box Culvert 76E DATE 7/20/91 BY BDO CHKD RJT

Riprap Plunge Basin Design (Q10)



Check Rock Size (From Figure XI-2, HEC No. 14)

For $y_o = 1.77$ $d_{50} = 6"$ or $0.50'$

$d_{50}/y_o = \frac{0.50'}{1.77'} = 0.28$, $F = 1.39$

$\frac{h_s}{y_o} = 1.02$ $h_s = 1.02(1.77) = 1.81'$

Check $\frac{h_s}{d_{50}} = \frac{1.81'}{0.50'} = 3.62 < 4$ and > 2 OK

Length of Basin

$10\,h_s = 10(1.81) = 18.1'$

or

$3(W_o) = 3(10) = 30'$

Use 30'

Culvert 76 E

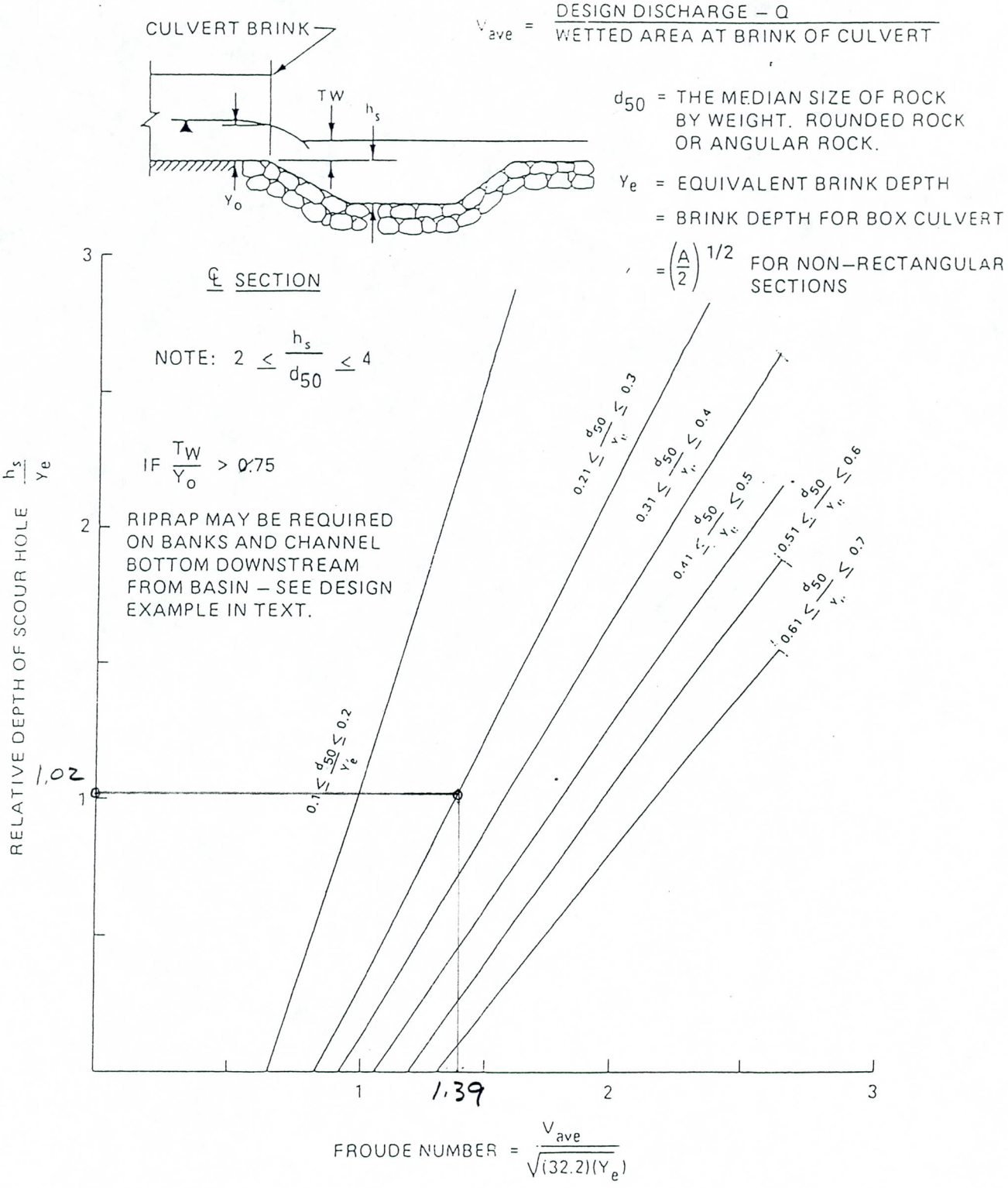


FIGURE X1–2. RELATIVE DEPTH OF SCOUR HOLE VERSUS FROUDE NUMBER AT BRINK OF CULVERT WITH RELATIVE SIZE OF RIPRAP AS A THIRD VARIABLE

SVERDRUP

JOB 40477 Toyota SHEET NO. 8 OF

COMPUTATIONS FOR Box Culvert 76E DATE 7/20/91 BY BDO CHKD RJT

$TW/Y_o = \frac{3.7}{1.77} = 2.09 > 0.75$ ∴ Check downstream riprap lining for channel protection.

Utilize figure XI-3 for existing average velocity along channel. Compute equivalent circular diameter D_e for brink area from:

$A = \pi D_e^2/4 = Y_o(W_o) = 1.77(10) = 17.7\ ft^2$

$D_e = (17.7(4)/\pi)^{1/2} = 4.75'$

From downstream cross section Q10 velocity is 5.4 fps. Culvert outlet velocity is 10.5 fps.

L/D_e	L	V_L/V_o	V_L	
10	47.5	.59	6.2	
15	71.3	.36	3.8	
12	57.0	.50	5.2	OK

∴ Need riprap lining for approximately 55 feet from the end of the culvert outlet apron.

SVERDRUP

JOB 40477 Toyota

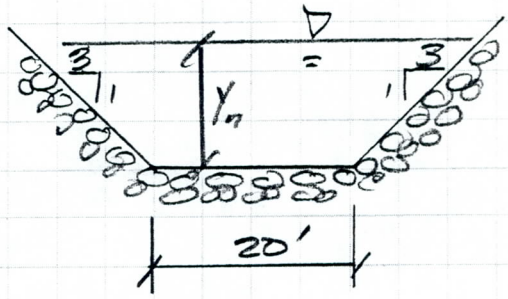
COMPUTATIONS FOR Channel Downstream of Culvert 76 E

SHEET NO. 9 OF

DATE 7/26/91

BY BDO CHKD RJT

Channel Design



$Q100 = 817$ cfs

$n = 0.032$ (6" Rock)

$S_o = 0.007$ ft/ft

$Y_n = 3.61'$

$A = 111.2$ ft^2

$WP = 2(11.42) + 20' = 42.84$ ft

$R_h = A/WP = 111.2/42.84 = 2.5957'$

$$V = \frac{1.49}{0.032}(2.5957)^{.666}(.007)^{.5} = 7.35 \text{ fps}$$

Check

$Q = VA = 7.35\,(111.2) = 817$ cfs

Energy Grade Line $= 3.61 + \frac{(7.35)^2}{2 \cdot 32.2} = 4.44'$.

∴ Make channel 4.5' deep

Froude Number

$$FF = \frac{7.35}{\sqrt{32.2 \times 3.61}} = 0.68, \text{ Subcritical}$$

SVERDRUP

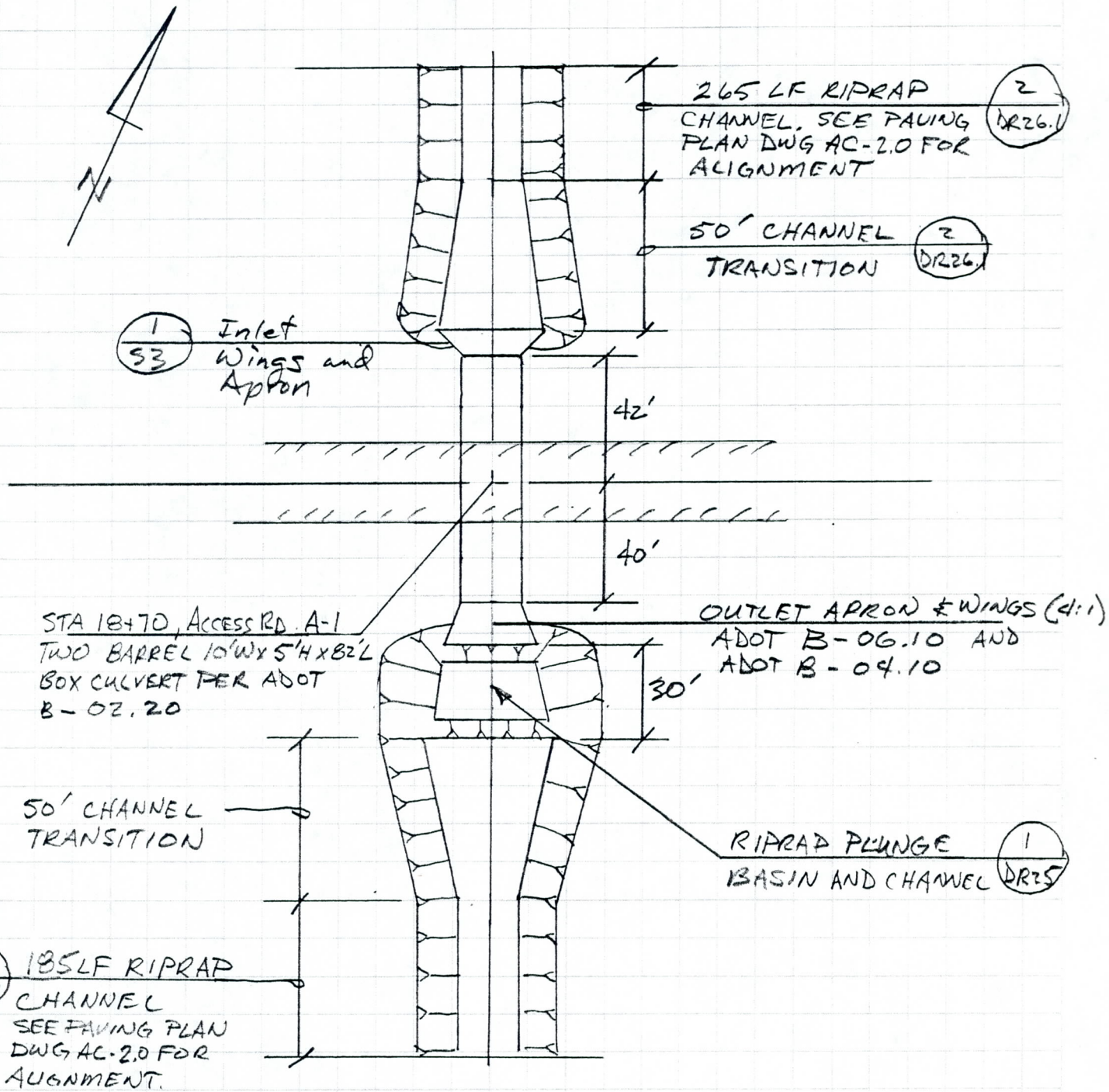
JOB 40477 Toyota

COMPUTATIONS FOR Culvert 76E [39]

SHEET NO. 10 OF

DATE 7/27/91

BY BDO CHKD RTT



[39] BOX CULVERT PLAN

STA 18+70, ACCESS RD A-1

SEE PROFILE DWG DR-14.0

Scale 1" = 50'

SVERDRUP

JOB 40477 Toyota

COMPUTATIONS FOR Culvert 76 E 39

SHEET NO. 11 OF

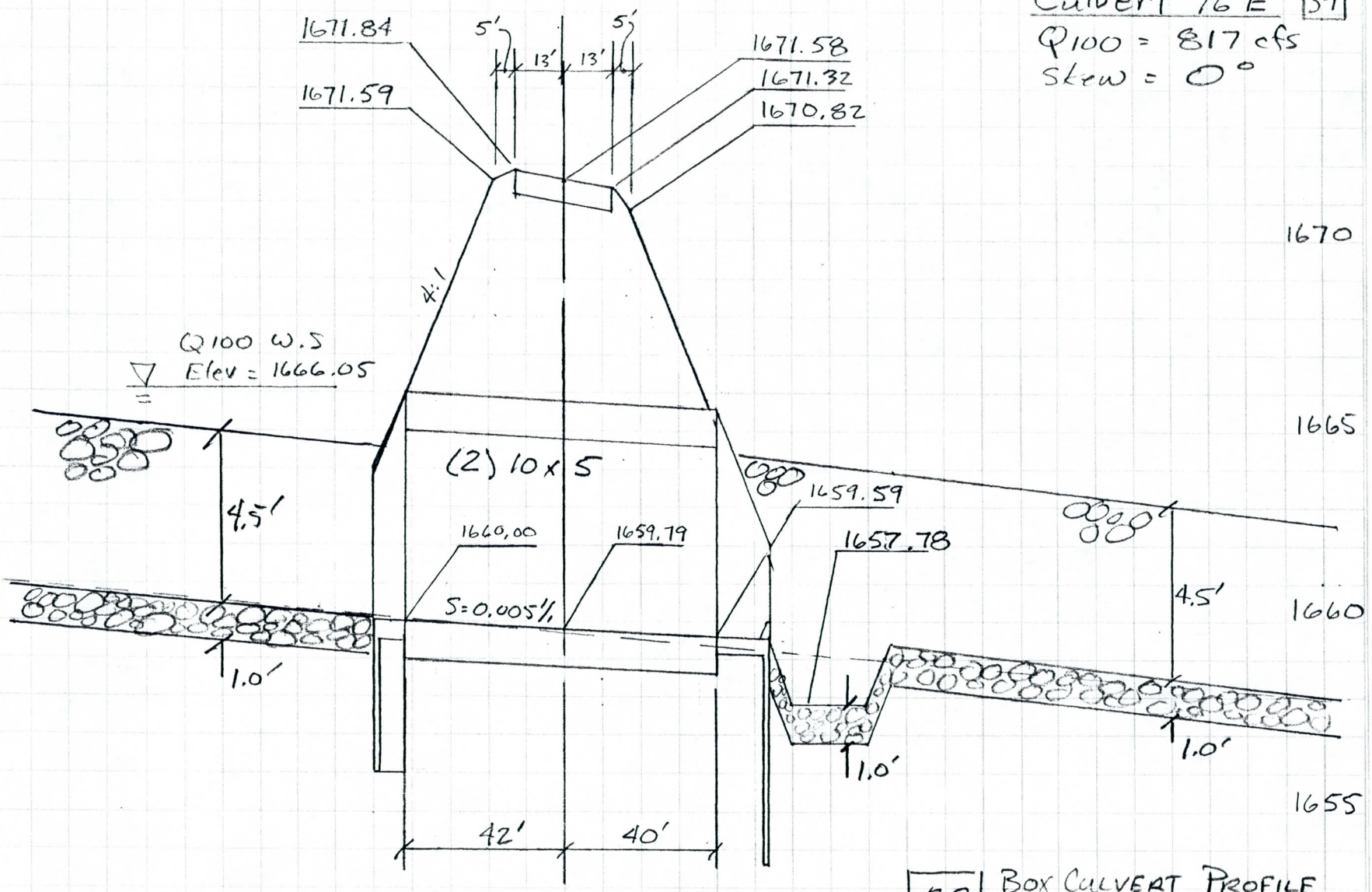
DATE 7/18/91

BY BDO CHKD RVT

Culvert 76 E 39

Q100 = 817 cfs

Skew = 0°



℄
18+70
Access Road

39 Box Culvert Profile
STA 18+70, Access Rd A-1
SEE PLAN DWG DR-6.0

Scale 1" = 40' Horiz
1" = 4' Vert.

SECTION NUMBER TW76E 7/18/91

Channel Slope: 0.0077 ft./ft.

CROSS SECTION DATA:

OFFSET	92.6	187.3	192.7	195.7	204.1	233.8	236.8	239.2	282.4
ELEV.	69.3	67.44	61.13	61.16	63.84	64.16	64.05	64.46	65.78
N	N/A	0.035	0.04	0.025	0.04	0.035	0.025	0.035	0.035

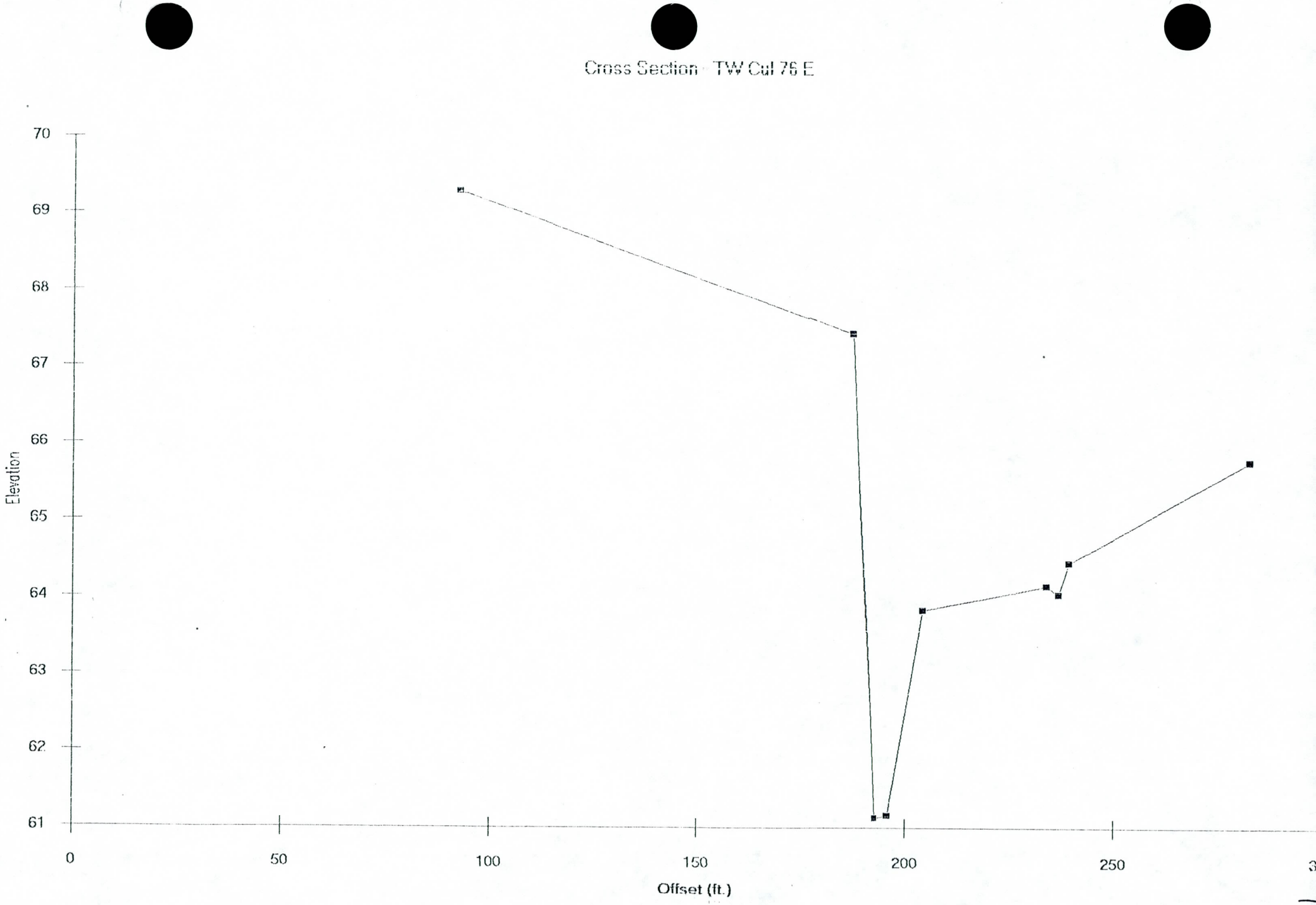
STAGE-DISCHARGE DATA:

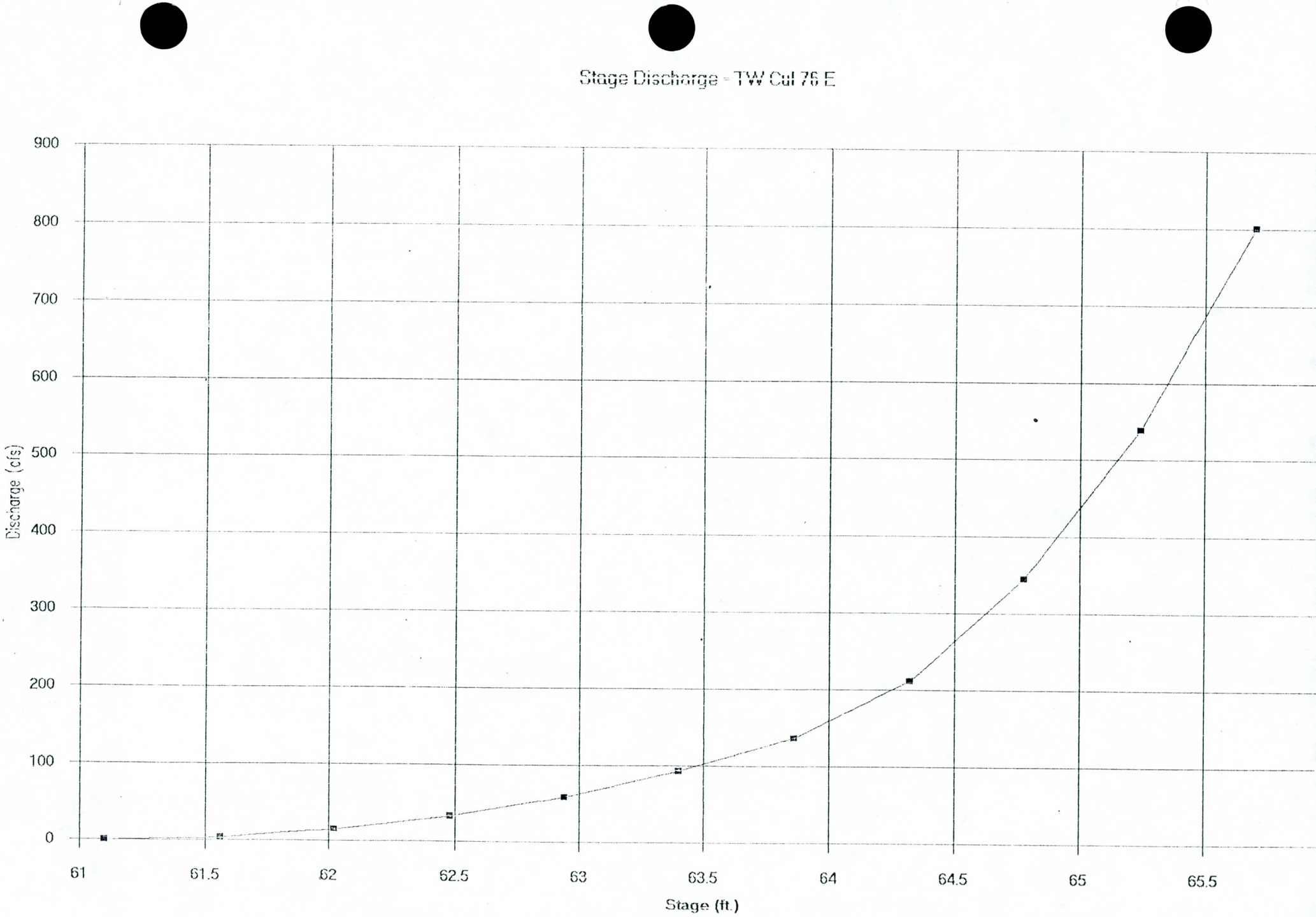
STAGE:	61.1													
WET PER.		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
AREA		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYD.RAD.		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Q		0	0	0	0	0	0	0	0	0	0	0	0	0
STAGE:	61.56													
WET PER.		0.0	0.6	3.0	1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
AREA		0.0	0.1	1.2	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYD.RAD.		0.0	0.1	0.4	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Q		0	0	4	0	0	0	0	0	0	0	0	0	0
STAGE:	62.02													
WET PER.		0.0	1.2	3.0	2.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
AREA		0.0	0.3	2.6	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYD.RAD.		0.0	0.3	0.9	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Q		0	0	13	2	0	0	0	0	0	0	0	0	0
STAGE:	62.48													
WET PER.		0.0	1.8	3.0	4.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
AREA		0.0	0.8	4.0	2.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYD.RAD.		0.0	0.4	1.3	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Q		0	1	25	7	0	0	0	0	0	0	0	0	0
STAGE:	62.94													
WET PER.		0.0	2.4	3.0	5.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
AREA		0.0	1.4	5.4	5.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYD.RAD.		0.0	0.6	1.8	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Q		0	3	41	14	0	0	0	0	0	0	0	0	0
STAGE:	63.4													
WET PER.		0.0	3.0	3.0	7.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
AREA		0.0	2.2	6.8	7.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYD.RAD.		0.0	0.7	2.3	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Q		0	6	61	27	0	0	0	0	0	0	0	0	0

SECTION NUMBER TW76E 7/18/91

STAGE:	63.86													
WET PER.		0.0	3.6	3.0	8.8	1.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
AREA		0.0	3.2	8.1	11.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYD.RAD.		0.0	0.9	2.7	1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Q		0	10	83	44	0	0	0	0	0	0	0	0	0	0
STAGE:	64.32														
WET PER.		0.0	4.2	3.0	8.8	29.7	3.0	1.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0
AREA		0.0	4.4	9.5	15.3	9.5	0.6	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYD.RAD.		0.0	1.0	3.2	1.7	0.3	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Q		0	15	107	72	17	1	0	0	0	0	0	0	0	0
STAGE:	64.78														
WET PER.		0.0	4.8	3.0	8.8	29.7	3.0	2.4	12.9	0.0	0.0	0.0	0.0	0.0	0.0
AREA		0.0	5.7	10.9	19.2	23.2	2.0	1.3	2.9	0.0	0.0	0.0	0.0	0.0	0.0
HYD.RAD.		0.0	1.2	3.6	2.2	0.8	0.7	0.5	0.2	0.0	0.0	0.0	0.0	0.0	0.0
Q		0	21	134	105	73	8	0	4	0	0	0	0	0	0
STAGE:	65.24														
WET PER.		0.0	5.4	3.0	8.8	29.7	3.0	2.4	28.0	0.0	0.0	0.0	0.0	0.0	0.0
AREA		0.0	7.2	12.3	23.0	36.8	3.4	2.4	12.3	0.0	0.0	0.0	0.0	0.0	0.0
HYD.RAD.		0.0	1.3	4.1	2.6	1.2	1.1	1.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0
Q		0	29	164	142	158	19	0	27	0	0	0	0	0	0
STAGE:	65.7														
WET PER.		0.0	6.0	3.0	8.8	29.7	3.0	2.4	43.0	0.0	0.0	0.0	0.0	0.0	0.0
AREA		0.0	8.9	13.7	26.9	50.5	4.8	3.5	28.6	0.0	0.0	0.0	0.0	0.0	0.0
HYD.RAD.		0.0	1.5	4.6	3.0	1.7	1.6	1.4	0.7	0.0	0.0	0.0	0.0	0.0	0.0
Q		0	38	196	184	268	34	0	81	0	0	0	0	0	0

W.S. Elev.	61.1	61.56	62.02	62.48	62.94	63.4	63.86	64.32	64.78	65.24	65.7
Q	0	4	15	33	59	93	137	212	345	539	801
A	0.0	1.6	4.1	7.5	11.8	16.8	22.8	39.5	63.9	95.1	133.4
V	0.0	2.5	3.7	4.4	5.0	5.5	6.0	5.4	5.4	5.7	6.0


Cross Section - TW Cul 76 E
70
69
68
67
66
65
64
63
62
61
Elevation
0
50
100
150
200
250
Offset (ft.)


Stage Discharge - TW Cul 75 E
900
800
700
600
500
400
300
200
100
0
Discharge (cfs)
61
61.5
62
62.5
63
63.5
64
64.5
65
65.5
Stage (ft.)

JOB 40 Toyota

COMPUTATIONS FOR Culvert 76F 40

SHEET NC ____ OF ____

DATE 7/91

BY BDO CHKD RJT

CULVERT COMPUTATION SHEET

PROJECT: ____

STATION: 20+50, Access Rd A-1

DESIGNER: ____

DATE: ____

HYDROLOGIC AND CHANNEL INFORMATION

262 (76F) / 127 (76G) / 399

DRAINAGE AREA 0.50 Sq miles

Q_1 = 399 cfs

Q_2 = ____

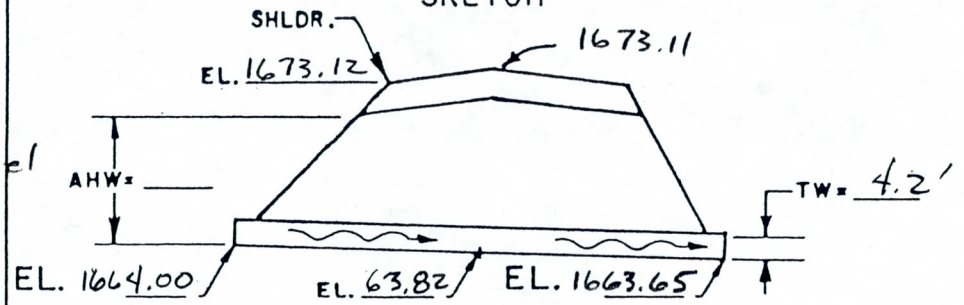
TW_1 = 4.2' Exist. Channel

TW_2 = ____

(Q_1 = DESIGN DISCHARGE, SAY ~~Q_{25}~~ Q_{100})

(Q_2 = CHECK DISCHARGE, SAY Q_{50})

SKETCH



S_0 = 0.0050' L = 70' L/100 S_0 = ____

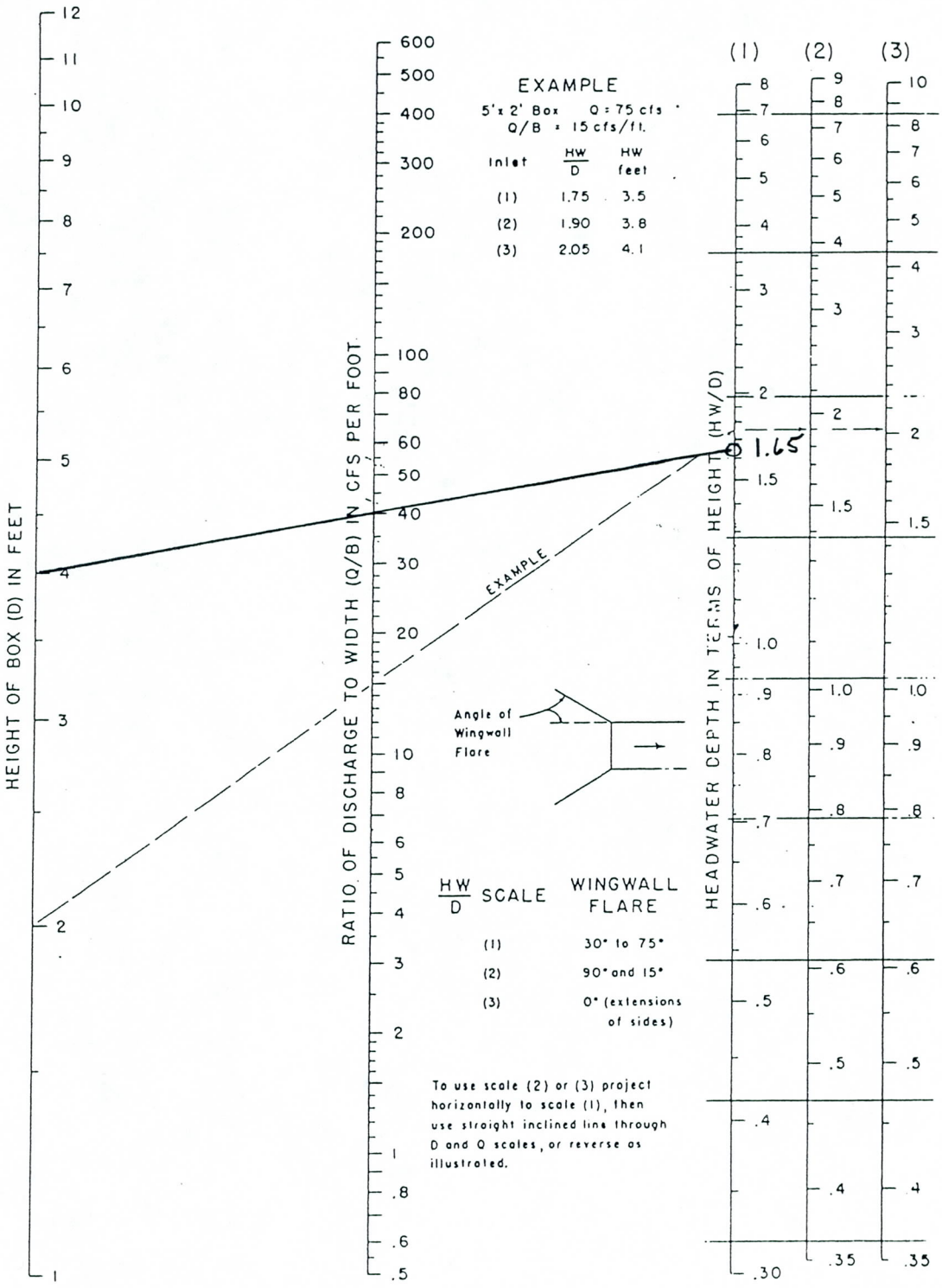
MEAN STREAM VELOCITY = 6.1 fps

CULVERT DESCRIPTION SIZE	CULVERT DESCRIPTION ENTR. TYPE	Q	CAP. CHART HW	HEADWATER COMPUTATION: INLET CONT. HW/D	INLET CONT. HW	OUTLET CONTROL K_e	OUTLET CONTROL H	OUTLET CONTROL d_c	OUTLET CONTROL $\frac{d_c+D}{2}$	OUTLET CONTROL TW	OUTLET CONTROL H_0	OUTLET CONTROL LS_0	OUTLET CONTROL HW	CONTROL HW	OUTLET VELOCITY	COST	DHW ELEV.	COMMENTS
(1) Barrel 10x4	Drop Inlet	399		1.65	6.6	0.2	2.1	3.7'	3.85'	4.2	4.2	.35'	5.95	6.6	13.3		1670.60	Inlet Control

SUMMARY & RECOMMENDATIONS Use riprap plunge basin for erosion control at outlet to box culvert.

Culvert 76 F

CHART I

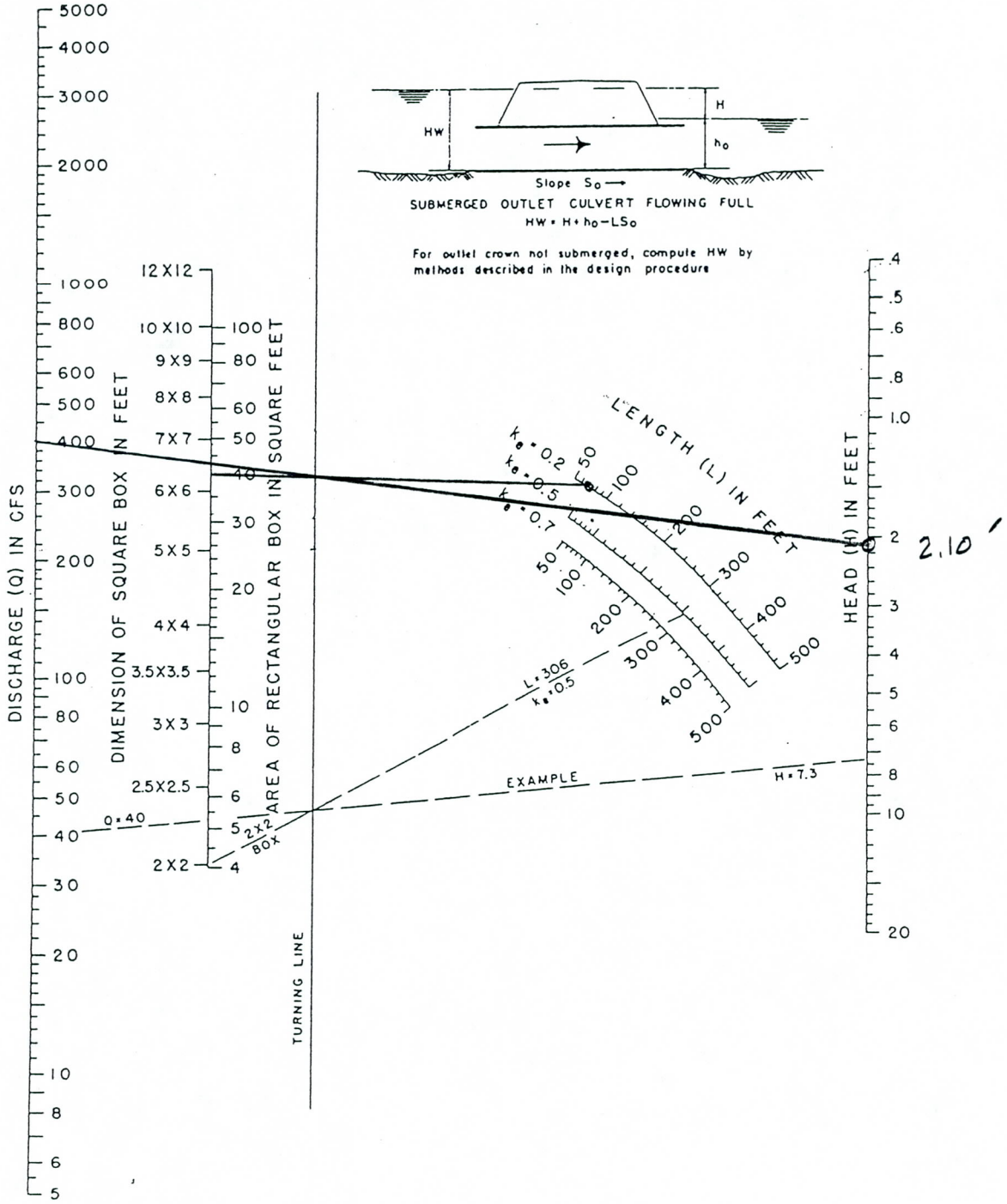


HEADWATER DEPTH FOR BOX CULVERTS WITH INLET CONTROL

BUREAU OF PUBLIC ROADS JAN. 1953

Culvert 76 F

CHART 8

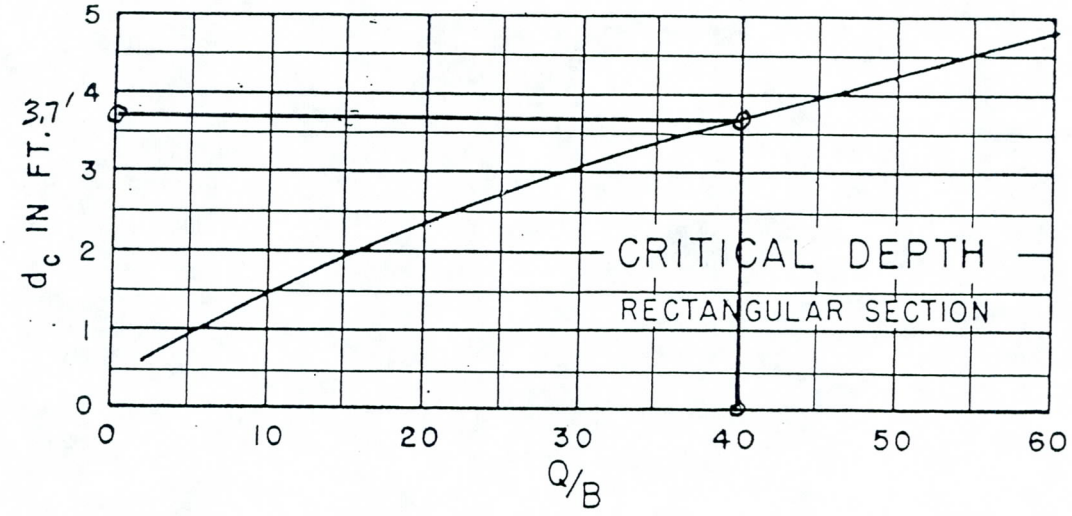


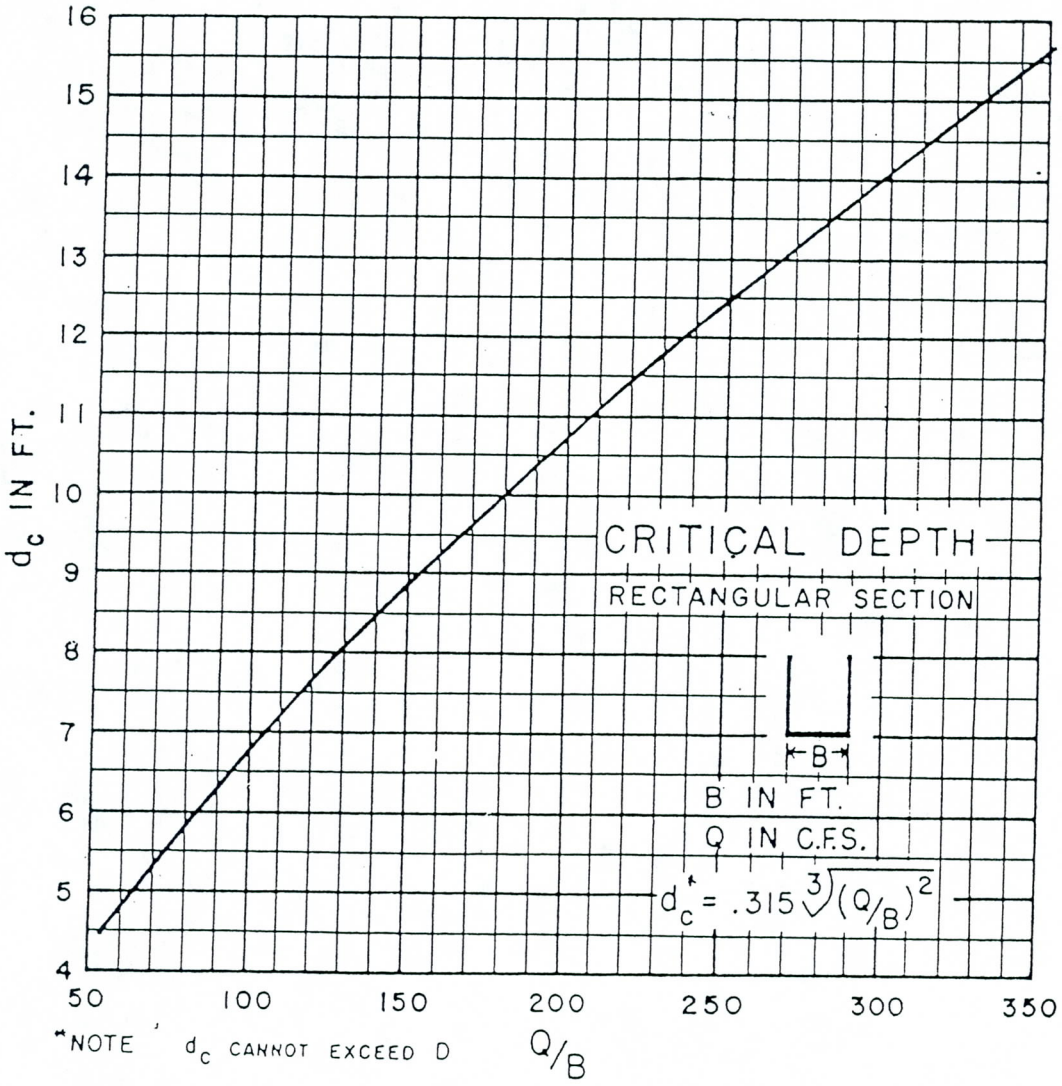
HEAD FOR
CONCRETE BOX CULVERTS
FLOWING FULL
n = 0.012

BUREAU OF PUBLIC ROADS JAN. 1963

Culvert 76 F

CHART 15





*NOTE d_c CANNOT EXCEED D

BUREAU OF PUBLIC ROADS JAN 1963

SVERDRUP

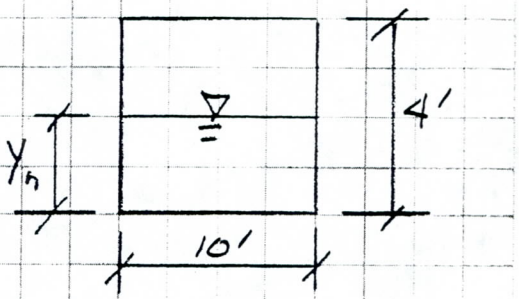
JOB 40477 Toyota SHEET NO. 5 OF

COMPUTATIONS FOR Culvert 76 F DATE 7/27/91

BY BDO CHKD RJT

Check depth of Flow using Manning Eqn.

$Q100 = 399$ cfs



$n = 0.012$

$S_o = 0.0050$ ft/ft

$Y_n \sim 3.00'$

$A = 30.0$ ft^2

$WP = 2(3.00) + 10 = 16.00$ ft

$R_h = A/WP = 30.0/16.0 = 1.8750$

$V = \frac{1.49}{.012}(1.8750)^{.666}(.005)^{.5} = 13.34$ fps

Check

$Q = VA = 13.34\,(30.0) = 400$ cfs (OK)

Check Froude Number

$$\# = \frac{V}{\sqrt{g \times Y_n}} = \frac{13.34}{\sqrt{32.2 \times 3.00}} = 1.36$$, Supercritical

$123 + 67 = 190$ cfs

$Q10 = 190$ cfs

$Y_n = 1.80'$, Velocity $= 10.56$ fps, $\# = 1.39$

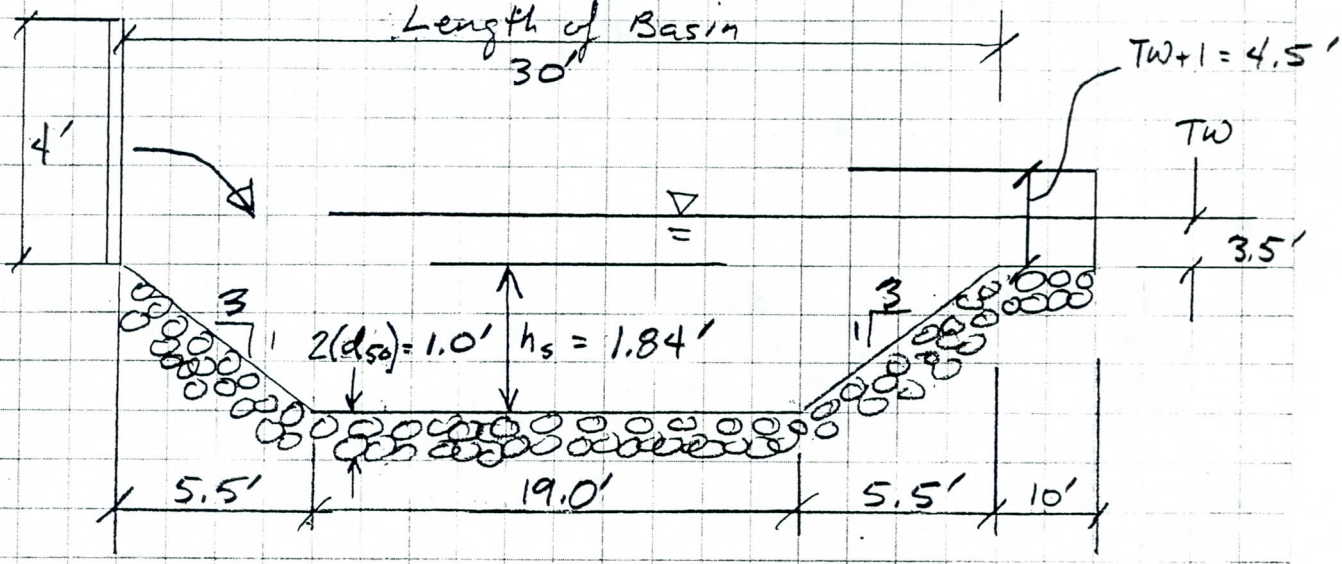
SVERDRUP

JOB 40477 Toyota SHEET NO. 6 OF

COMPUTATIONS FOR Box Culvert 76F DATE 7/27/91

BY BDO CHKD RJT

Riprap Plunge Basin Design (Q10)



Check Rock Size (From Figure XI-2, HEC No. 14)

For $y_o = 1.80'$ $d_{50} = 6''$ or $0.50'$

$d_{50}/y_o = \frac{0.50'}{1.80'} = 0.28$, $F = 1.39$

$\frac{h_s}{y_o} = 1.02$ $h_s = 1.02(1.80) = 1.84$

Check $\frac{h_s}{d_{50}} = \frac{1.84'}{0.50'} = 3.68 < 4$ and > 2

∴ OK

Length of Basin

$10\,h_s = 10(1.84') = 18.4'$

or

$3(W_o) = 3(10') = 30'$

Use 30'

Culvert 76 F

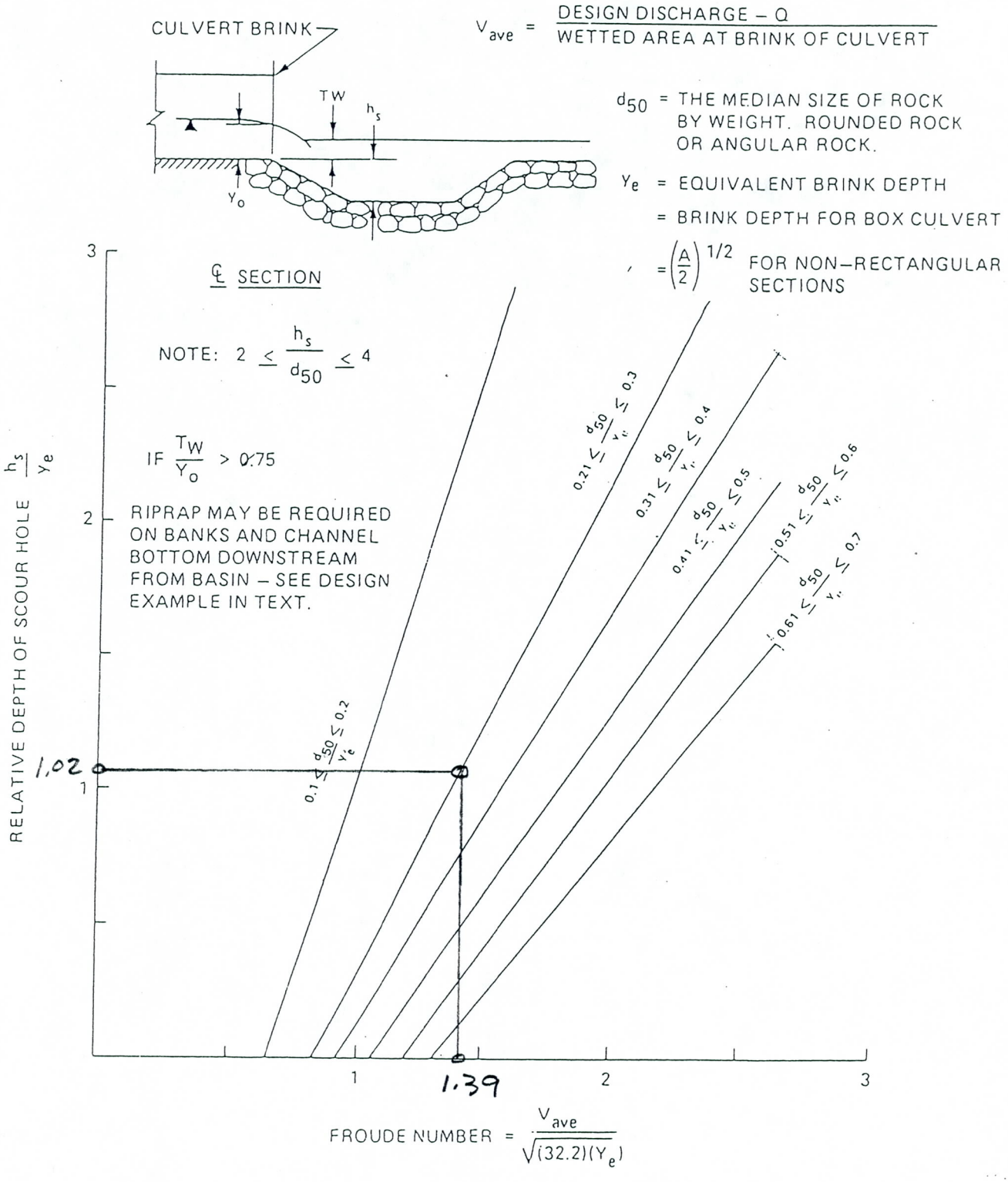


FIGURE X1–2. RELATIVE DEPTH OF SCOUR HOLE VERSUS FROUDE NUMBER AT BRINK OF CULVERT WITH RELATIVE SIZE OF RIPRAP AS A THIRD VARIABLE

SVERDRUP

JOB 40477 Toyota

COMPUTATIONS FOR Box Culvert 76F

SHEET NO. 8 OF

DATE 7/22/91

BY BDO CHKD RJT

$TW/Y_o = \frac{3.5}{1.80'} = 1.94 > 0.75$ ∴ Check downstream riprap lining for channel protection.

Utilize figure XI-3 for existing average velocity along channel. Compute equivalent circular diameter D_e for brink area from:

$A = \pi D_e^2/4 = Y_o(W_o) = 1.80(10) = 18.0$

$D_e = (18.0(4)/\pi)^{1/2} = 4.79'$

From downstream cross section Q 10 velocity is 6.8 fps. Culvert outlet velocity is 10.6 fps.

L/D_e	L	V_L/V_o	V_L	
10	47.9'	.59	6.2	
9	43.1'	.64	6.8	OK

∴ Need riprap lining for approximately 43 feet from the end of the culvert outlet apron.

SVERDRUP

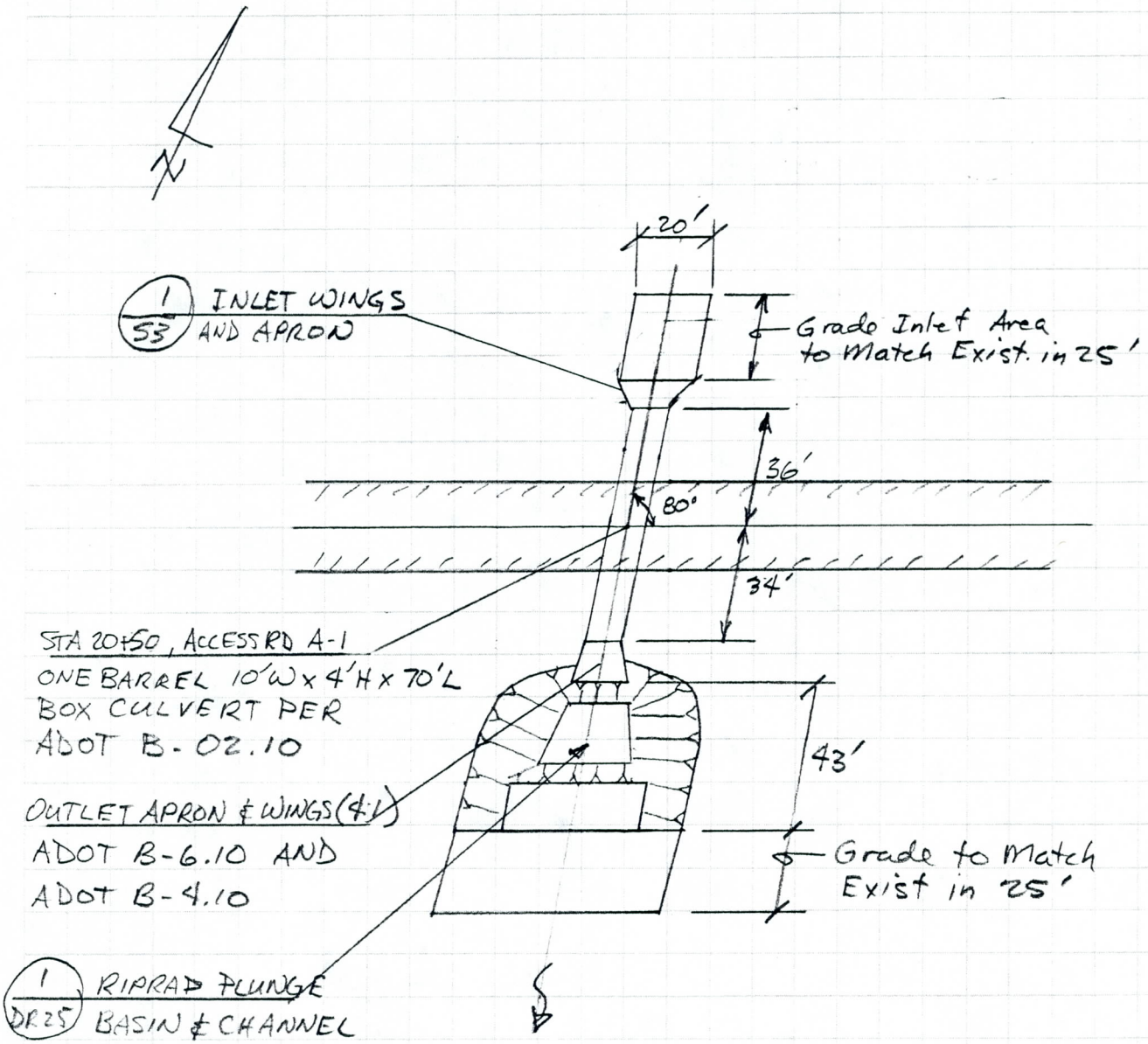
JOB 40477 Toyota

COMPUTATIONS FOR Culvert 76 F [40]
Plan View

SHEET NO. 9 OF

DATE 7/27/91

BY BDO CHKD RJT



[40] BOX CULVERT PROFILE
STA 20+50, ACCESS RD A-1
SEE PROFILE DWG DR-14.0
SCALE 1"=50'

SVERDRUP

JOB 40477 Toyota

COMPUTATIONS FOR Culvert Profile 70F

Cornering Course Sta 58+80

SHEET NO. 10 OF

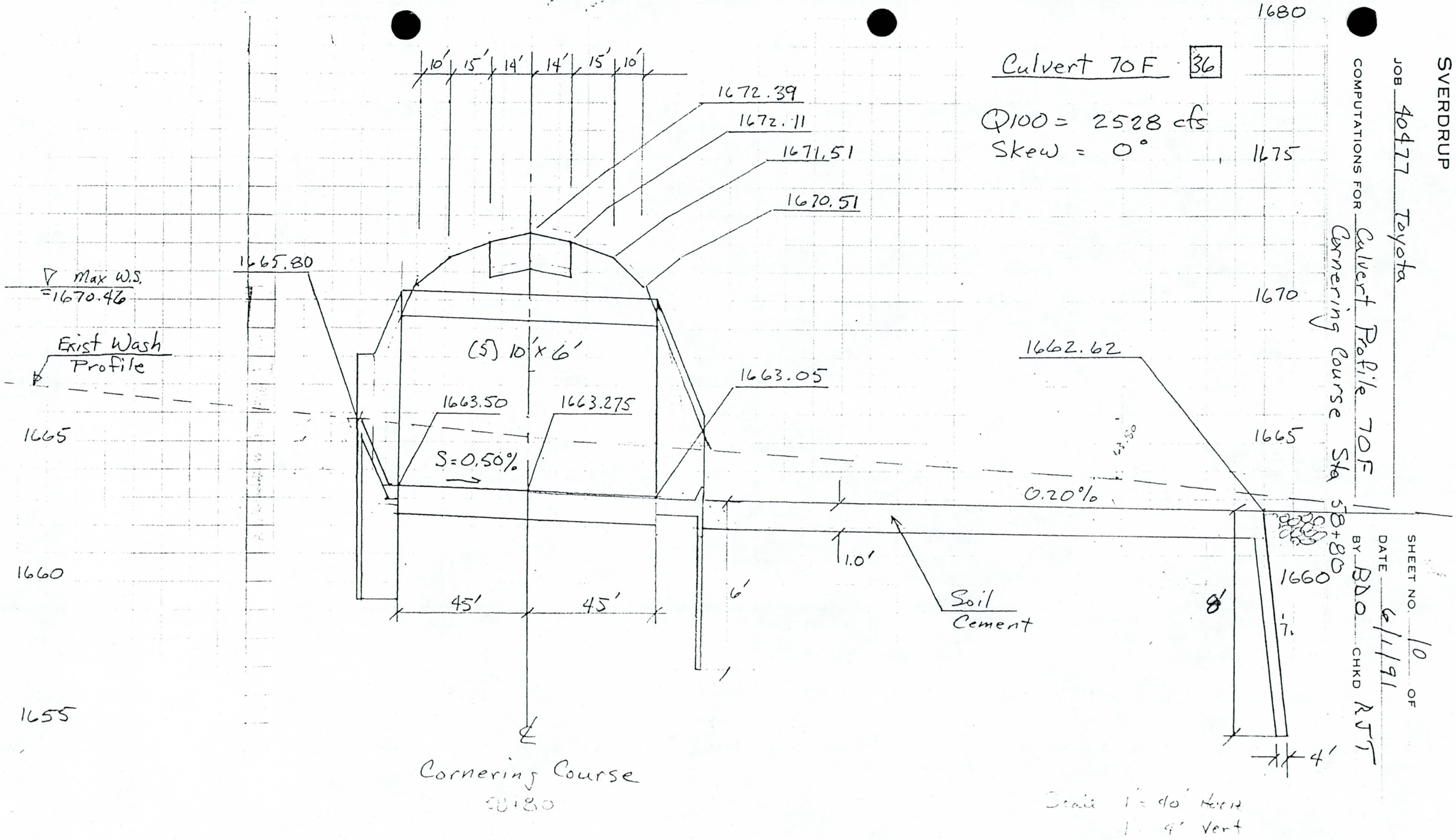
DATE 6/4/91

BY BDO CHKD RJT

Culvert 70F 36

Q100 = 2528 cfs

Skew = 0°



Scale 1" = 10' Horiz
1" = 5' Vert

SVERDRUP

JOB 40477 Toyota

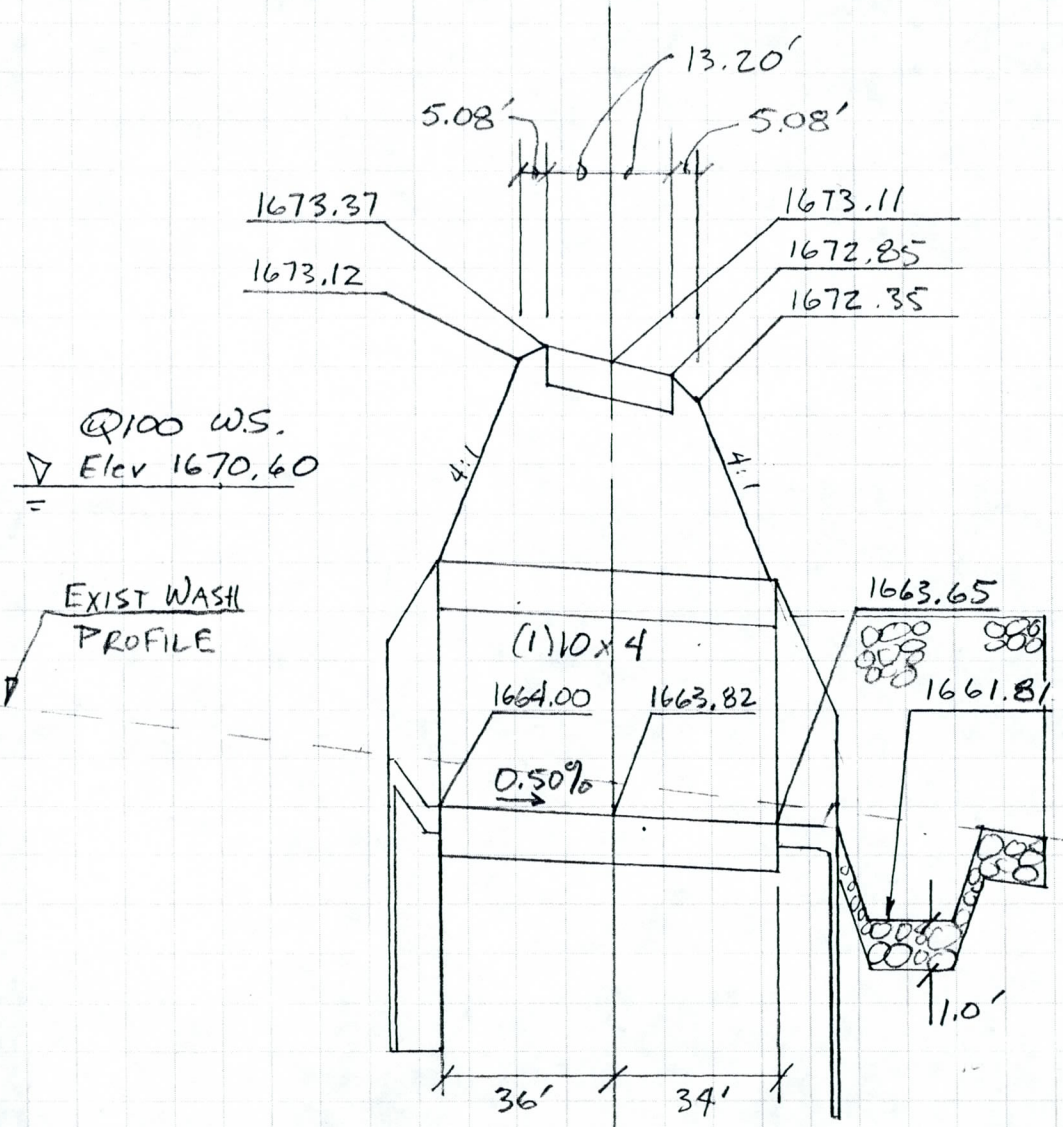
COMPUTATIONS FOR Culvert 76F Prof. 40

SHEET NO. 10 OF

DATE 7/27/91

BY BDO CHKD RVT

Culver 76 F
Skew = 10° Rt.
Q100 = 399 cfs



℄
Access Road A-1
Sta 20+50

40 BOX CULVERT PROFILE
STA 20+50, ACCESS RD A-1
SEE PLAN DWG DR-6.0
SCALE 1" = 40' Horiz., 1" = 4' Vert.

SECTION NUMBER TW76F 7/27/91

Channel Slope: 0.0125 ft./ft.

CROSS SECTION DATA:

OFFSET	3.2	50.6	53.9	55.9	60.4	66	70.5	75	76.6	80.4	107.1
ELEV.	66.5	65.26	64.57	65	65.79	65.9	64.77	62	62.02	65.5	69.49
N	N/A	0.035	0.035	0.035	0.035	0.035	0.035	0.04	0.025	0.04	0.035

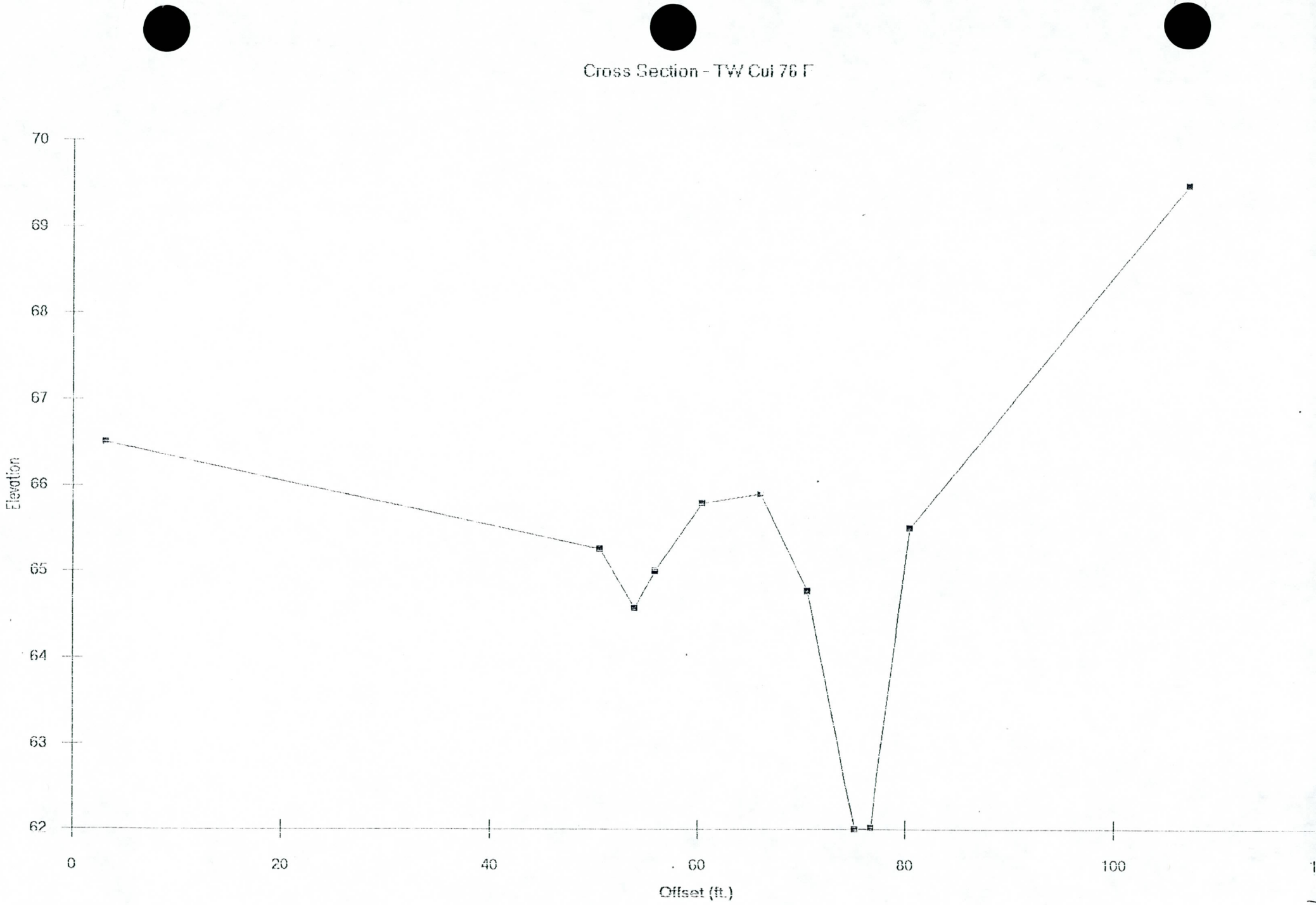
STAGE-DISCHARGE DATA:

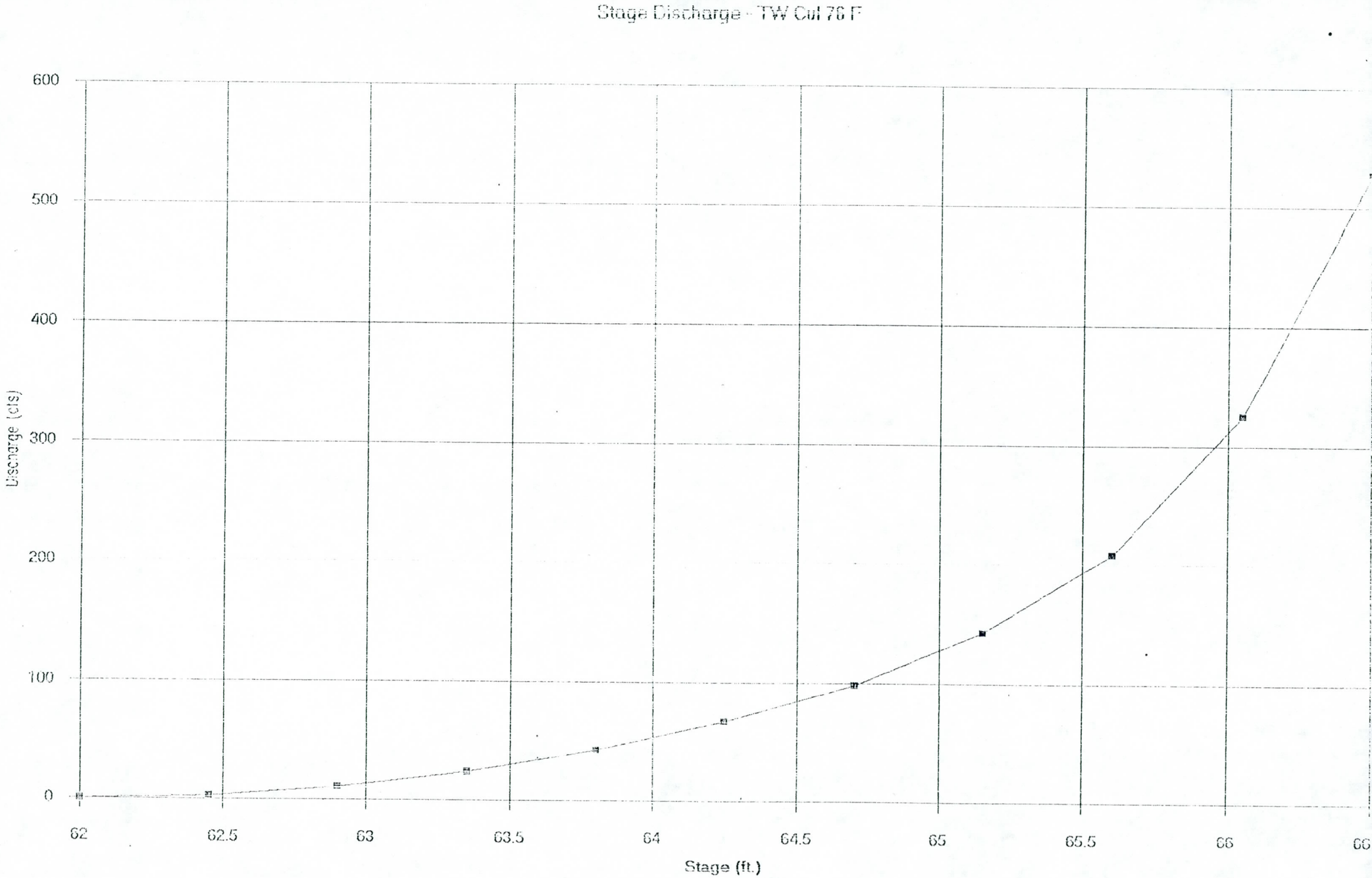
STAGE: 62														
WET PER.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
AREA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYD.RAD.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Q	0	0	0	0	0	0	0	0	0	0	0	0	0	0
STAGE: 62.45														
WET PER.	0.0	0.0	0.0	0.0	0.0	0.0	0.9	1.6	0.6	0.0	0.0	0.0	0.0	0.0
AREA	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.7	0.1	0.0	0.0	0.0	0.0	0.0
HYD.RAD.	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.4	0.2	0.0	0.0	0.0	0.0	0.0
Q	0	0	0	0	0	0	0	3	0	0	0	0	0	0
STAGE: 62.9														
WET PER.	0.0	0.0	0.0	0.0	0.0	0.0	1.7	1.6	1.3	0.0	0.0	0.0	0.0	0.0
AREA	0.0	0.0	0.0	0.0	0.0	0.0	0.7	1.4	0.4	0.0	0.0	0.0	0.0	0.0
HYD.RAD.	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.9	0.3	0.0	0.0	0.0	0.0	0.0
Q	0	0	0	0	0	0	1	9	1	0	0	0	0	0
STAGE: 63.35														
WET PER.	0.0	0.0	0.0	0.0	0.0	0.0	2.6	1.6	2.0	0.0	0.0	0.0	0.0	0.0
AREA	0.0	0.0	0.0	0.0	0.0	0.0	1.5	2.1	1.0	0.0	0.0	0.0	0.0	0.0
HYD.RAD.	0.0	0.0	0.0	0.0	0.0	0.0	0.6	1.3	0.5	0.0	0.0	0.0	0.0	0.0
Q	0	0	0	0	0	0	4	17	2	0	0	0	0	0
STAGE: 63.8														
WET PER.	0.0	0.0	0.0	0.0	0.0	0.0	3.4	1.6	2.6	0.0	0.0	0.0	0.0	0.0
AREA	0.0	0.0	0.0	0.0	0.0	0.0	2.6	2.9	1.7	0.0	0.0	0.0	0.0	0.0
HYD.RAD.	0.0	0.0	0.0	0.0	0.0	0.0	0.8	1.8	0.7	0.0	0.0	0.0	0.0	0.0
Q	0	0	0	0	0	0	9	28	5	0	0	0	0	0
STAGE: 64.25														
WET PER.	0.0	0.0	0.0	0.0	0.0	0.0	4.3	1.6	3.3	0.0	0.0	0.0	0.0	0.0
AREA	0.0	0.0	0.0	0.0	0.0	0.0	4.1	3.6	2.7	0.0	0.0	0.0	0.0	0.0
HYD.RAD.	0.0	0.0	0.0	0.0	0.0	0.0	1.0	2.2	0.8	0.0	0.0	0.0	0.0	0.0
Q	0	0	0	0	0	0	17	41	10	0	0	0	0	0

SECTION NUMBER TW76F 7/27/91

STAGE:	64.7													
WET PER.		0.0	0.6	1.3	0.0	0.0	0.0	5.2	1.6	4.0	0.0	0.0	0.0	0.0	0.0
AREA		0.0	0.0	0.1	0.0	0.0	0.0	5.9	4.3	3.9	0.0	0.0	0.0	0.0	0.0
HYD.RAD.		0.0	0.1	0.1	0.0	0.0	0.0	1.1	2.7	1.0	0.0	0.0	0.0	0.0	0.0
Q		0	0	0	0	0	0	27	55	16	0	0	0	0	0
STAGE:	65.15														
WET PER.		0.0	2.8	4.9	5.7	0.0	1.6	5.3	1.6	4.6	0.0	0.0	0.0	0.0	0.0
AREA		0.0	0.8	1.5	1.6	0.0	0.3	7.9	5.0	5.3	0.0	0.0	0.0	0.0	0.0
HYD.RAD.		0.0	0.3	0.3	0.3	0.0	0.2	1.5	3.1	1.2	0.0	0.0	0.0	0.0	0.0
Q		0	0	0	3	0	0	43	72	24	0	0	0	0	0
STAGE:	65.6														
WET PER.		13.0	16.4	18.4	21.9	0.0	3.4	5.3	1.6	5.2	0.7	0.0	0.0	0.0	0.0
AREA		2.2	4.5	6.1	7.1	0.0	1.4	10.0	5.7	7.0	0.0	0.0	0.0	0.0	0.0
HYD.RAD.		0.2	0.3	0.3	0.3	0.0	0.4	1.9	3.6	1.4	0.0	0.0	0.0	0.0	0.0
Q		0	0	0	16	0	4	63	89	36	0	0	0	0	0
STAGE:	66.05														
WET PER.		30.2	33.6	35.6	40.2	45.8	50.4	5.3	1.6	5.2	3.7	0.0	0.0	0.0	0.0
AREA		11.9	15.7	18.2	21.2	22.3	25.5	12.0	6.5	8.7	1.0	0.0	0.0	0.0	0.0
HYD.RAD.		0.4	0.5	0.5	0.5	0.5	0.5	2.3	4.0	1.7	0.3	0.0	0.0	0.0	0.0
Q		0	0	0	0	0	77	86	109	51	2	0	0	0	0
STAGE:	66.5														
WET PER.		47.4	50.8	52.8	57.4	63.0	67.6	5.3	1.6	5.2	6.8	0.0	0.0	0.0	0.0
AREA		29.4	34.6	38.0	43.0	46.7	51.9	14.0	7.2	10.4	3.3	0.0	0.0	0.0	0.0
HYD.RAD.		0.6	0.7	0.7	0.7	0.7	0.8	2.7	4.5	2.0	0.5	0.0	0.0	0.0	0.0
Q		0	0	0	0	0	207	112	130	69	10	0	0	0	0

W.S. Elev.	62	62.45	62.9	63.35	63.8	64.25	64.7	65.15	65.6	66.05	66.5
Q	0	3	11	24	43	67	99	143	208	325	527
A	0.0	1.0	2.5	4.6	7.2	10.4	14.2	20.2	31.2	53.7	86.9
V	0.0	3.2	4.4	5.2	5.9	6.5	6.9	7.1	6.7	6.1	6.1


Cross Section - TW Cul 76 F
70
69
68
67
66
65
64
63
62
Elevation
0
20
40
60
80
100
Offset (ft.)


Stage Discharge - TW Cul 76 F
600
500
400
300
200
100
0
Discharge (cfs)
62
62.5
63
63.5
64
64.5
65
65.5
66
Stage (ft.)

SVERDRUP

JOB 40177 Toyota SHEET NO. ____ OF ____

COMPUTATIONS FOR Culvert No. 41 DATE 9/6/91

BY BDO CHKD RJT

CULVERT COMPUTATION SHEET

PROJECT: ____

STATION: 4+15, Access Rd G1

DESIGNER: ____

DATE: ____

HYDROLOGIC AND CHANNEL INFORMATION

DRAINAGE AREA ____

Q_1 = 41 cfs TW_1 = N/A

Q_2 = ____ TW_2 = ____

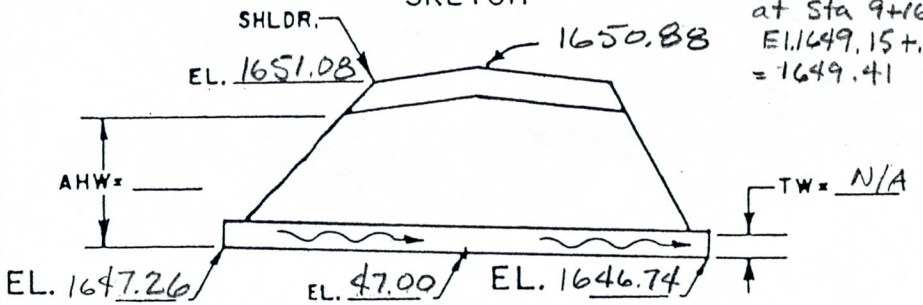
Assume maximum flow through pipe @ HW/D = 1.0 due to dip section @ Sta 9+16, with 0.6' of flow over dip section.

(Q_1 = DESIGN DISCHARGE, SAY Q_{25})

(Q_2 = CHECK DISCHARGE, SAY Q_{50})

SKETCH

Low Point G1 at Sta 9+16 El. 1649.15 + .26 = 1649.41



S_o = 0.01% L = 52' L/100 S_o = ____

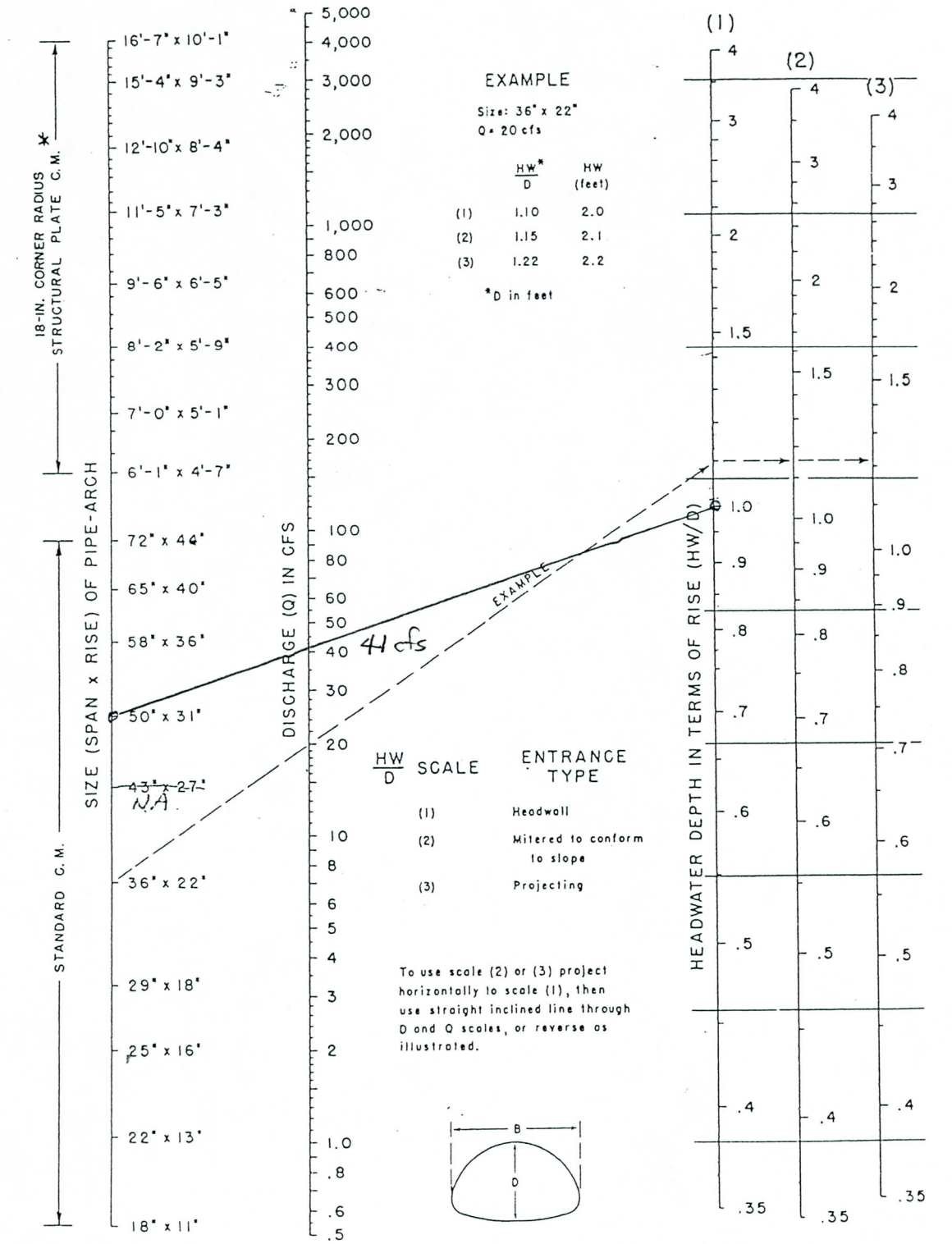
MEAN STREAM VELOCITY = N/A

CULVERT DESCRIPTION		Q	CAP. CHART HW	HEADWATER COMPUTATION										CONTROL HW	OUTLET VELOCITY	COST	DHW ELEV.	COMMENTS
				INLET CONT.		OUTLET CONTROL $HW = H + h_o - LS_o$												
SIZE	ENTR. TYPE			HW/D	HW	K_e	H	d_c	$\frac{d_c + D}{2}$	TW	h_o	LS_o	HW					
cmpArch (1)49"x33"	End Section	41		1.0	2.75	0.5	0.95	1.50	2.13	–	2.13	0.52	2.56	2.75	5.9		1650.01	Inlet Control

SUMMARY & RECOMMENDATIONS Use dumped riprap downstream for erosion control.

Culvert No. 41

CHART 6



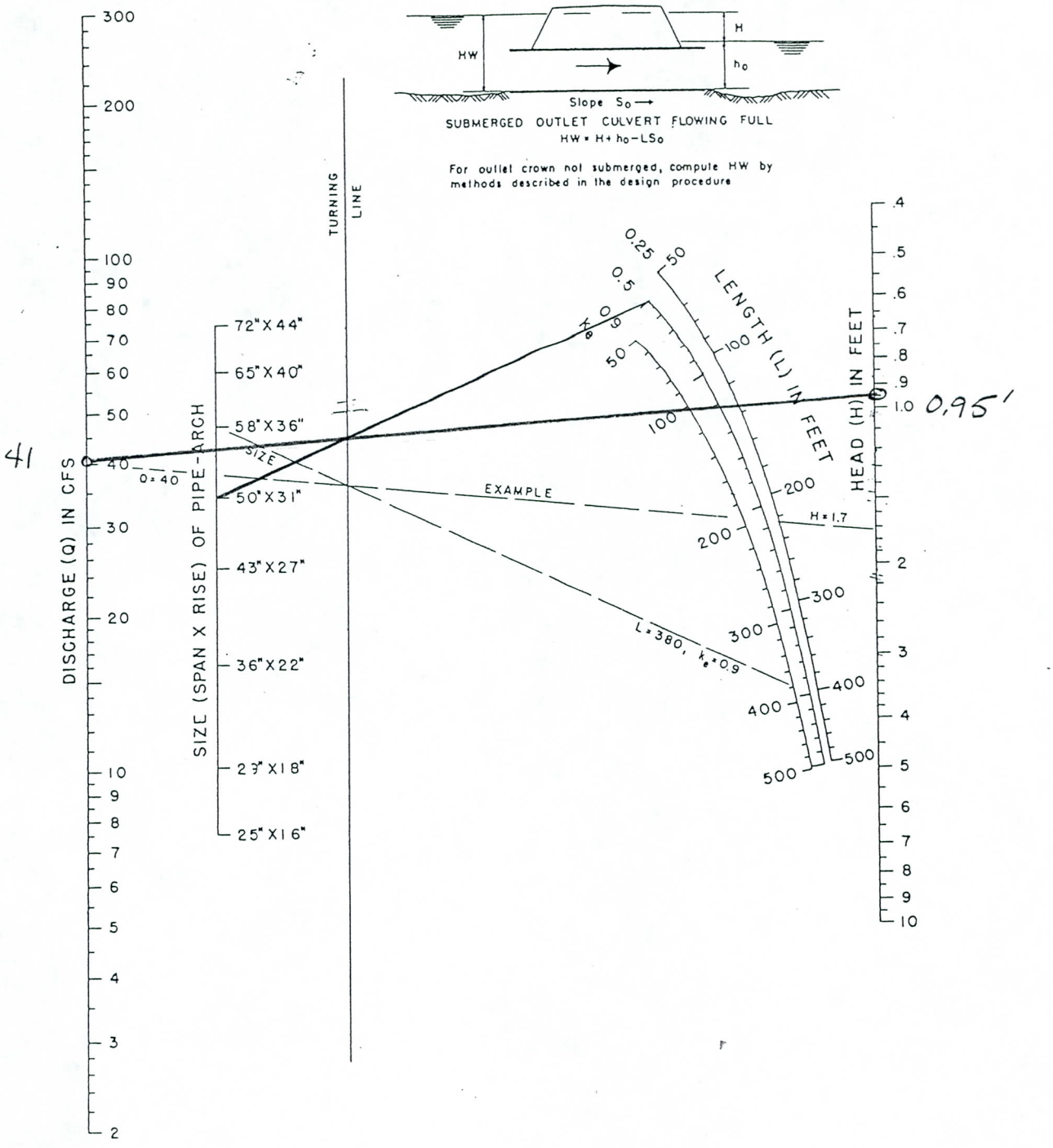
* ADDITIONAL SIZES NOT DIMENSIONED ARE LISTED IN FABRICATOR'S CATALOG

BUREAU OF PUBLIC ROADS JAN. 1963

HEADWATER DEPTH FOR C. M. PIPE-ARCH CULVERTS WITH INLET CONTROL

Culvert No. 41

CHART 12



41

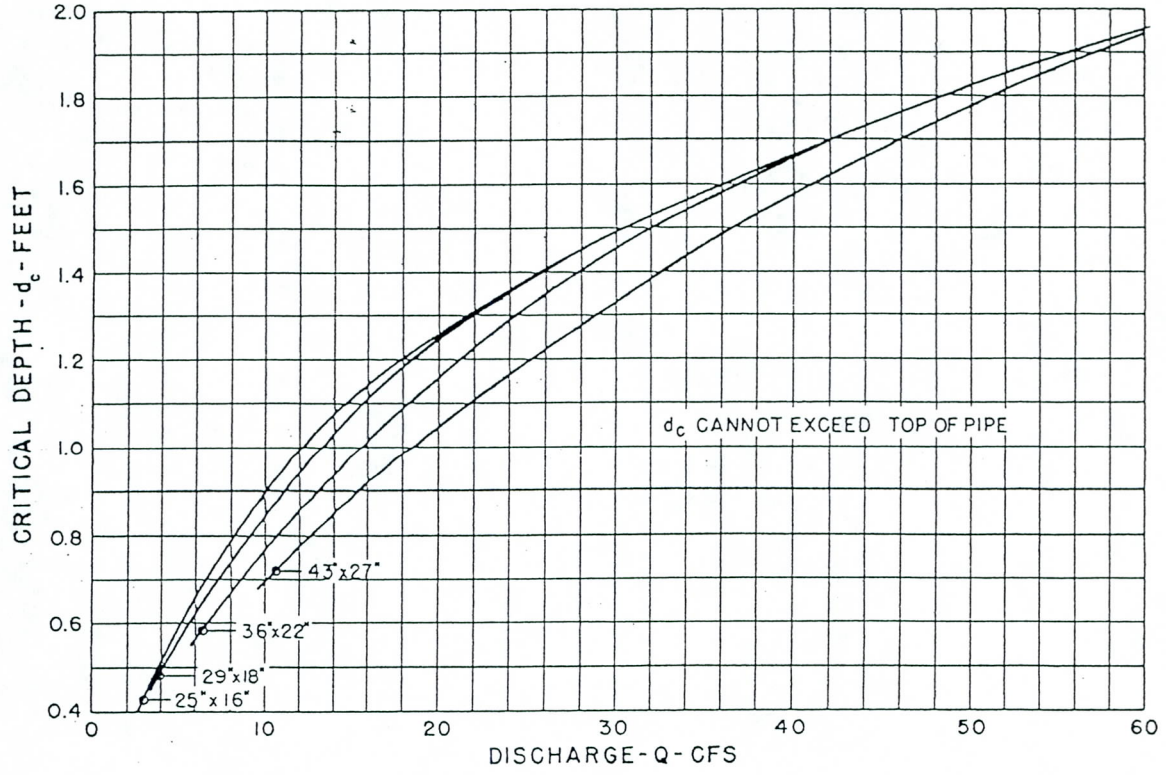
0.95'

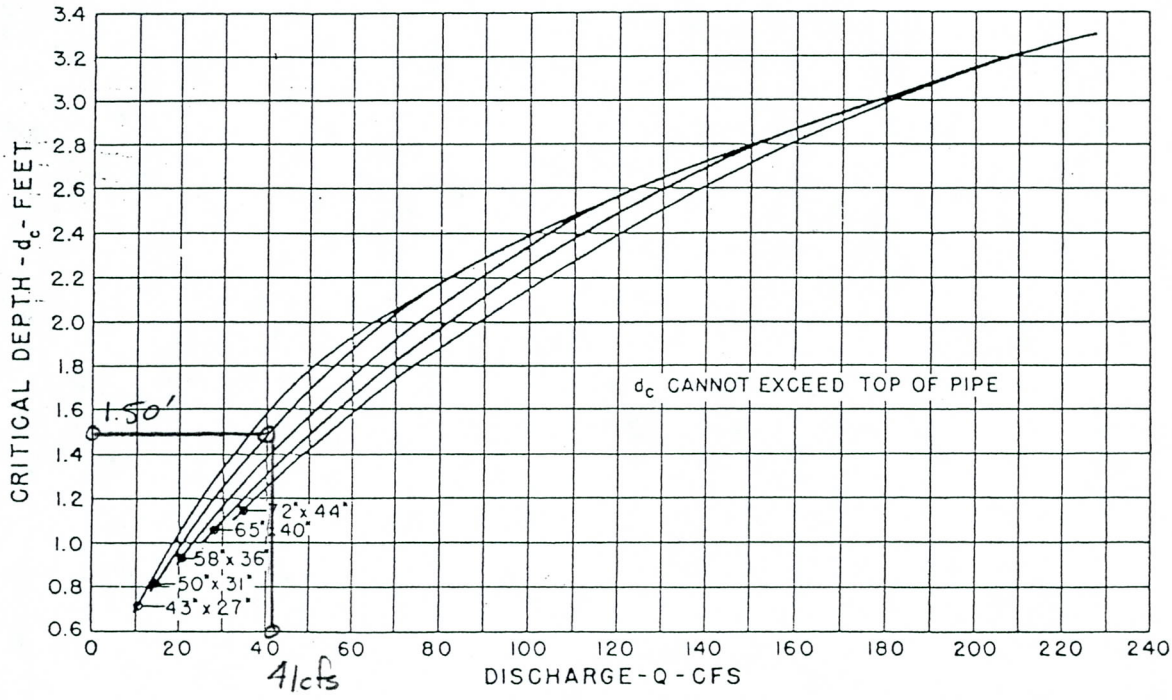
HEAD FOR
STANDARD C. M. PIPE-ARCH CULVERTS
FLOWING FULL
n=0.024

BUREAU OF PUBLIC ROADS JAN. 1963

Culvert No. 41

CHART 19





BUREAU OF PUBLIC ROADS

JAN. 1964

CRITICAL DEPTH
STANDARD C.M. PIPE-ARCH

SVERDRUP

JOB 40477 Toyota

SHEET NO. ____ OF ____

DATE 9/9/91

COMPUTATIONS FOR Culvert No. 41
Outlet Velocity

BY BDO CHKD RJT

From CMP Arch Pipe Table 4-15

For a Full Pipe (49" x 33")

Hydraulic Radius = 0.81 ft
Area = 8.90 ft²

Using Manning Eqn. w/ S = 0.01% & n = 0.024

$$Q = \frac{1.49}{.024}(8.90)(0.81)^{.666}(0.01)^{.5} = 48.0 \text{ cfs}$$

(From Figure 4-38)

$$\frac{Q_P}{Q_{Full}} = \frac{41}{48} = 0.854 \Rightarrow \frac{A}{A_{Full}} = 0.78$$

$$V = \frac{Q}{A} = \frac{41}{0.78(8.9)} = \underline{5.9 \text{ fps}}$$

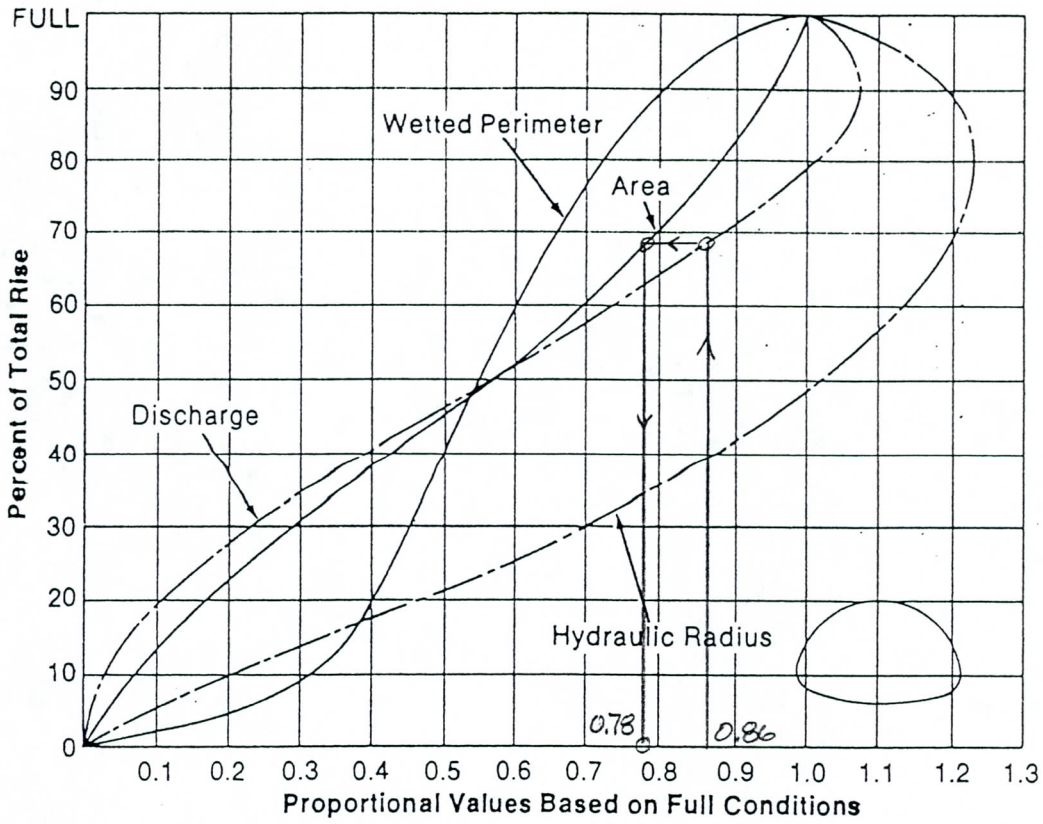


Figure 4-38 Hydraulic properties of corrugated steel and structural plate pipe-arches.

Table 4-15 Full-Flow Data for Corrugated Steel Pipe Arches

Corrugations 2⅔ × ½ in.					Corrugations 3 × 1 in. and 5 × 1 in.			
Dimensions, in.			Waterway Area, ft²	Hydraulic Radius A/πD, ft	Diameter, in.	Equiv. Size, in.	Waterway Area, ft²	Hydraulic Radius A/πD, ft
Pipe Diameter	Pipe-Arch Span	Pipe-Arch Rise						
15	17	13	1.1	0.280	54	60 × 46	15.6	1.104
18	21	15	1.6	0.340	60	66 × 51	19.3	1.230
21	24	18	2.2	0.400	66	73 × 55	23.2	1.343
24	28	20	2.9	0.462	72	81 × 59	27.4	1.454
30	35	24	4.5	0.573	78	87 × 63	32.1	1.573
36	42	29	6.5	0.69	84	95 × 67	37.0	1.683
*42	49	33	8.9	0.81	90	103 × 71	42.4	1.80
*48	57	38	11.6	0.924	96	112 × 75	48.0	1.911
*54	64	43	14.7	1.04	102	117 × 79	54.2	2.031
*60	71	47	18.1	1.153	108	128 × 83	60.5	2.141
*66	77	52	21.9	1.268	114	137 × 87	67.4	2.259
*72	83	57	26.0	1.38	120	142 × 91	74.5	2.373

SVERDRUP

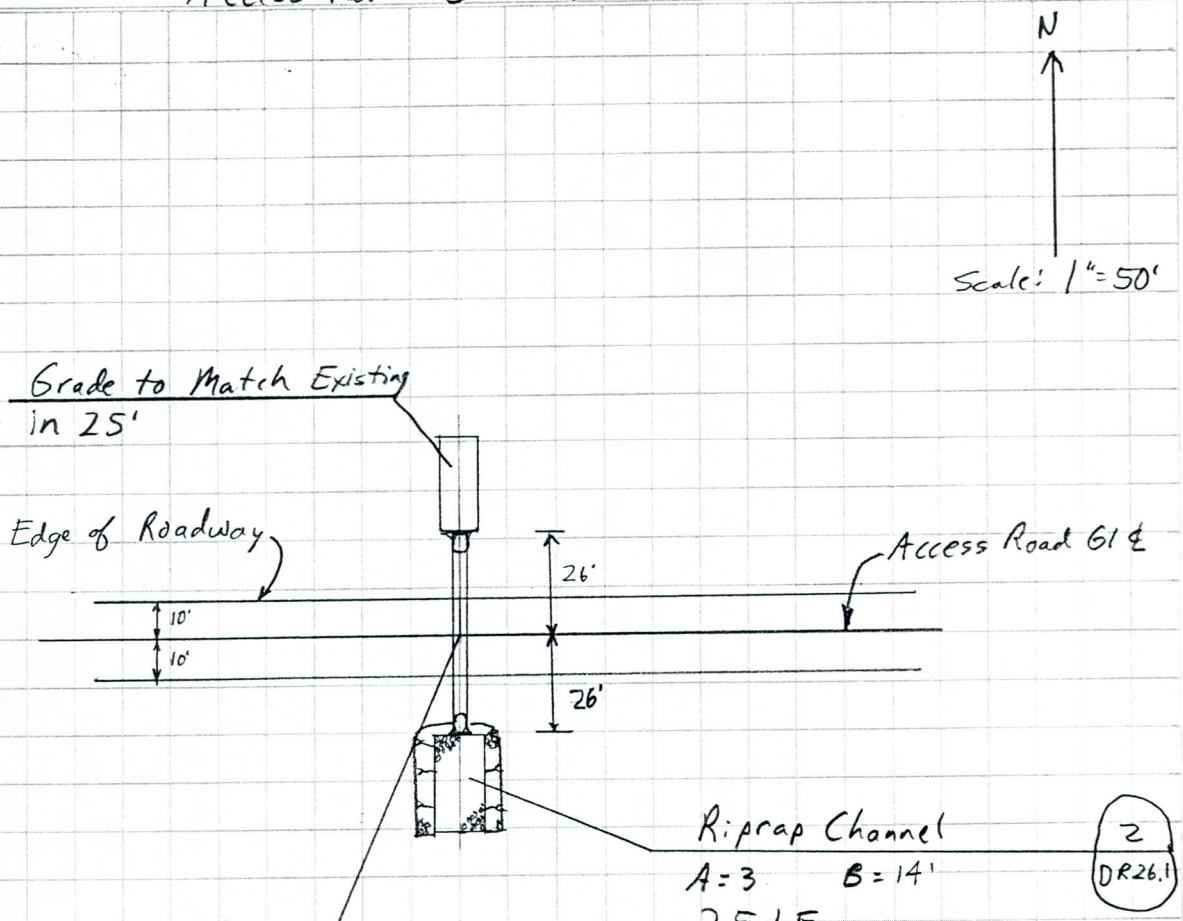
JOB 40477 Toyota

SHEET NO. _____ OF _____

DATE 9-8-91

COMPUTATIONS FOR Culvert 41 Plan View
Access Road G1 Sta 4+15

BY DEP CHKD RJT



41 Pipe Culvert Plan
Sta. 4+15 Access Road G1
See Profile Dwg. DR-14.1

SVERDRUP

JOB 40422 Toyota

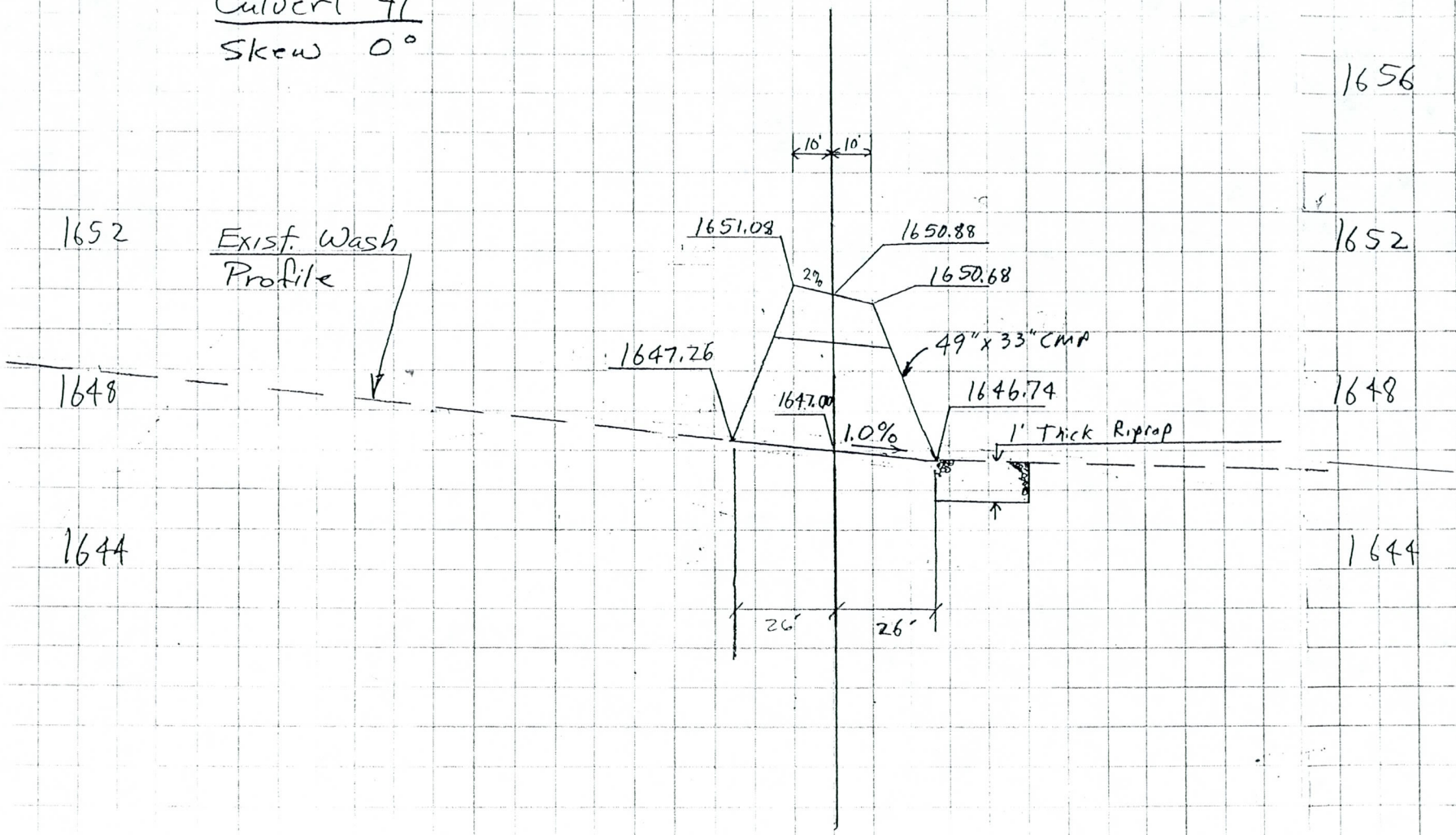
COMPUTATIONS FOR Culvert 41 Profile
Access Rd. G1 Sta. 4+15

BY DFP CHKD RJT

DATE 8-28-91

SHEET NO. ____ OF ____

Culvert 41
Skew 0°



Access Road G1 &
Sta. 4+15

Scale
Horiz 1" = 40'
Vert 1" = 4'

Pipe Culvert Profile 41
Sta. 4+15 Access Rd G1
See Plan Dwg. DR-6.1

SVERDRUP

JOB 404[redacted]7 Toyota

SHEET NO. ____ OF ____

DATE 9[redacted]10/91

COMPUTATIONS FOR Culvert No. 42 [42]
Access Road G1 Sta 8+95

BY BDO CHKD RJT

CULVERT COMPUTATION SHEET

PROJECT: ____

STATION: Access Road G1 @ Sta 8+95

DESIGNER: ____

DATE: ____

HYDROLOGIC AND CHANNEL INFORMATION

DRAINAGE AREA ____

Q_1 = 338 cfs* (0.5' water over road) TW_1 = N/A

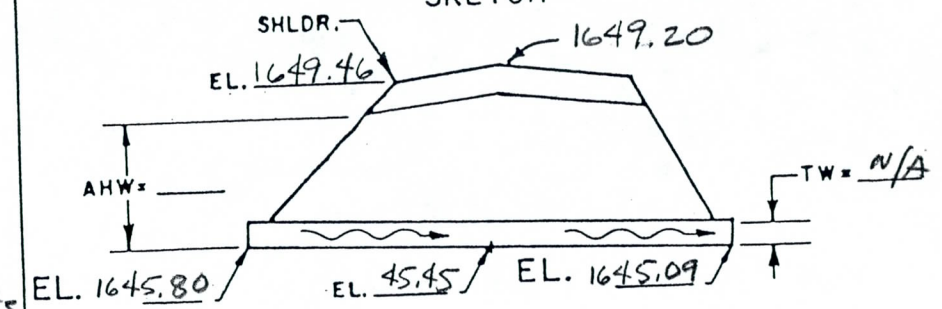
Q_2 = 104 cfs (no water over road) TW_2 = N/A

* 220 cfs over roadway w/ 118 cfs through culverts

Low Flow Crossing

(Q_1 = DESIGN DISCHARGE, SAY Q_{25})
(Q_2 = CHECK DISCHARGE, SAY Q_{50})

SKETCH



S_0 = 0.010 ft/ft L = 71' L/100 S_0 = ____

MEAN STREAM VELOCITY = N/A

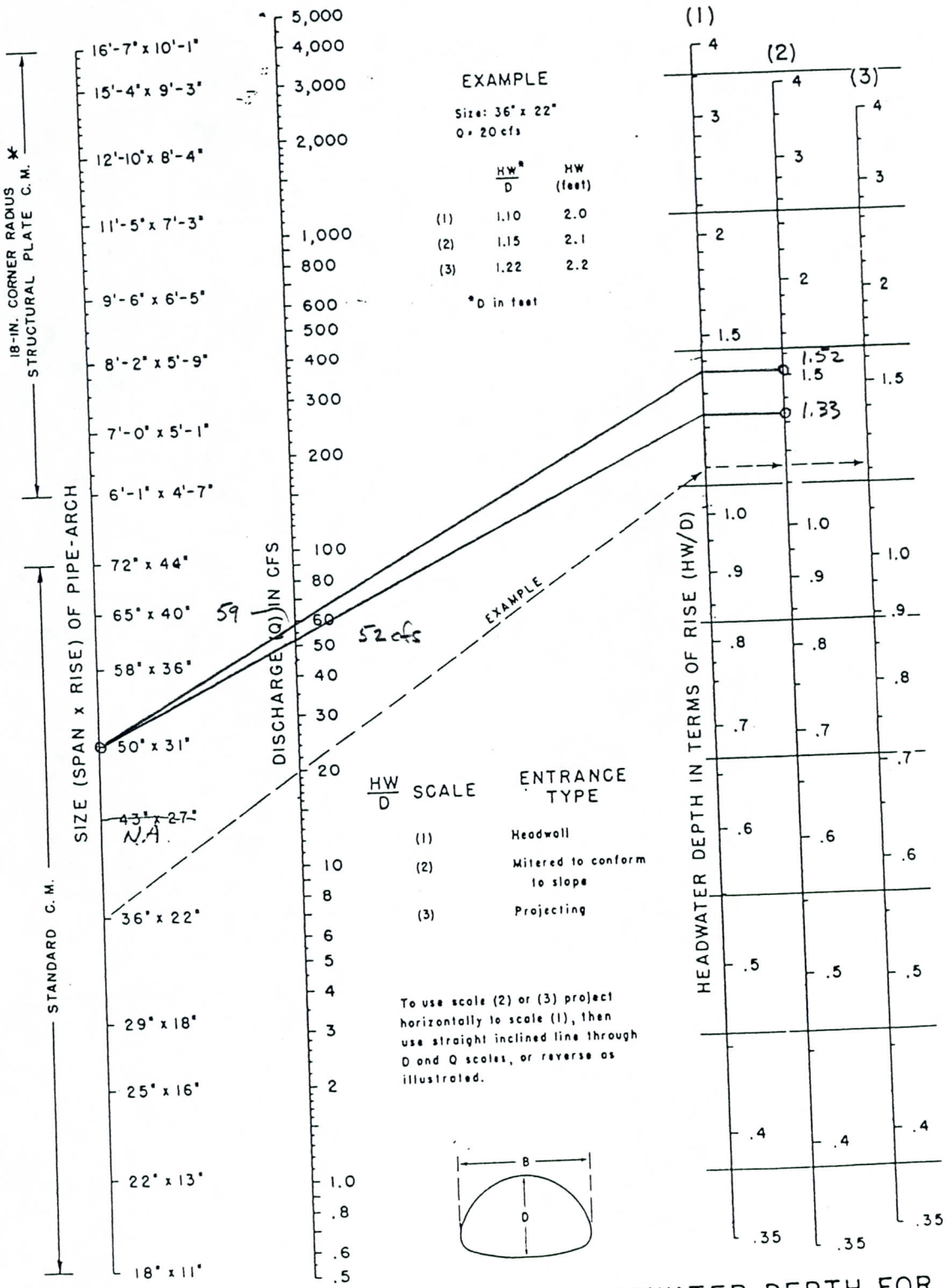
CULVERT DESCRIPTION SIZE	CULVERT DESCRIPTION ENTR. TYPE	Q	CAP. CHART HW	HEADWATER COMPUTATION: INLET CONT. HW/D	INLET CONT. HW	OUTLET CONTROL HW = H + h_o − LS_o: K_e	H	d_c	$\frac{d_c + D}{2}$	TW	h_o	LS_o	HW	CONTROL HW	OUTLET VELOCITY	COST	DHW ELEV.	COMMENTS
CMP Arch	Mitered	59 cfs		1.52	4.16	0.7	2.50	1.85	2.30	N/A	2.30	0.71	4.09	4.16	6.6		1649.96	Inlet control
(2) 49"x33"	Ends	52 cfs		1.33	3.66	0.7	1.94	1.72	2.24	N/A	2.24	0.71	3.47	3.66	6.2		1649.46	Inlet control
"	"																	

SUMMARY & RECOMMENDATIONS Use dumped riprap downstream of culvert for erosion protection. Soil cement embankment protection from Sta 7+50 to 10+00 for dip crossing.

B-10

Culvert No. 42

CHART 6



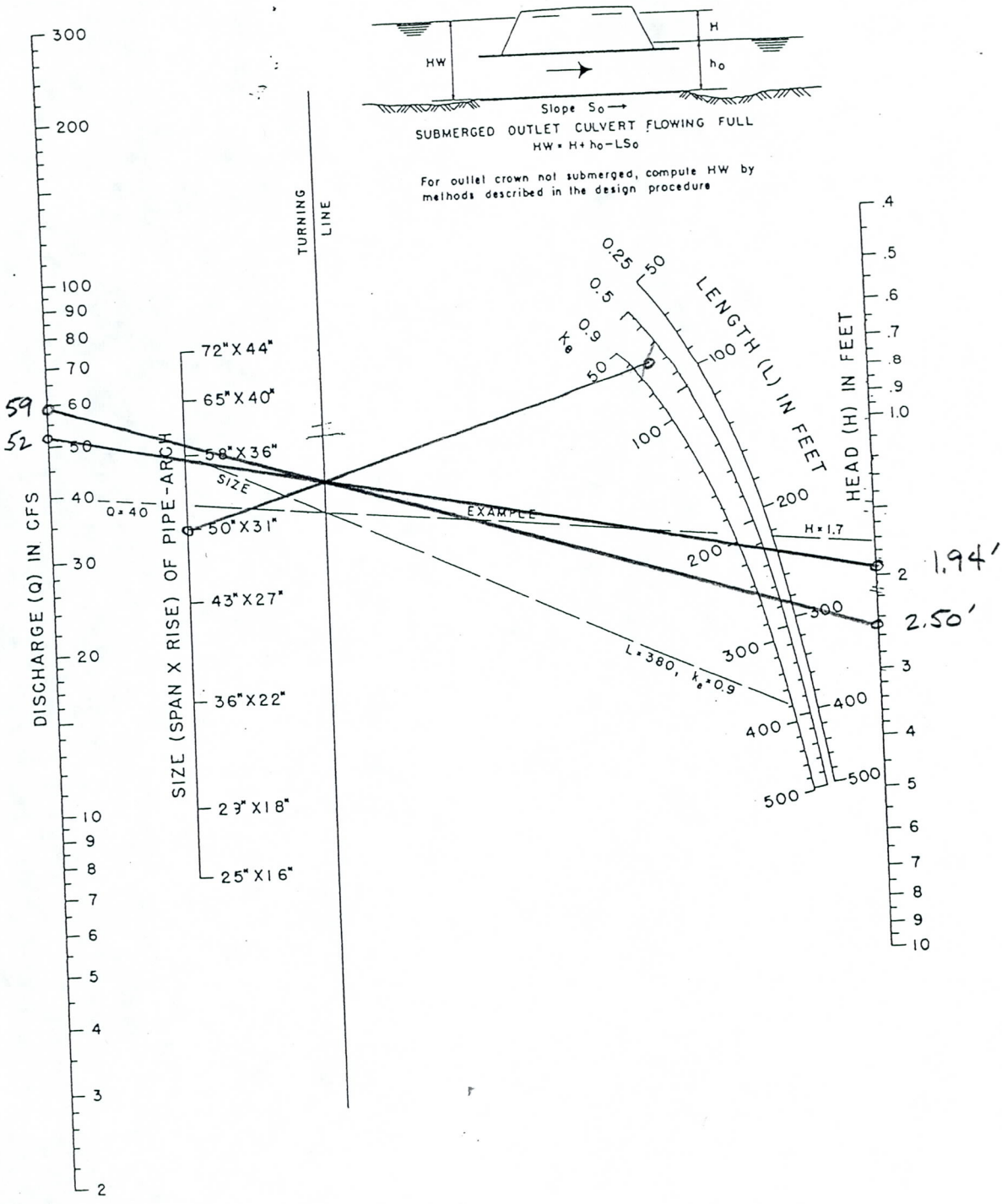
* ADDITIONAL SIZES NOT DIMENSIONED ARE LISTED IN FABRICATOR'S CATALOG

BUREAU OF PUBLIC ROADS JAN 1963

HEADWATER DEPTH FOR C. M. PIPE-ARCH CULVERTS WITH INLET CONTROL

Culvert No. 42

CHART 12

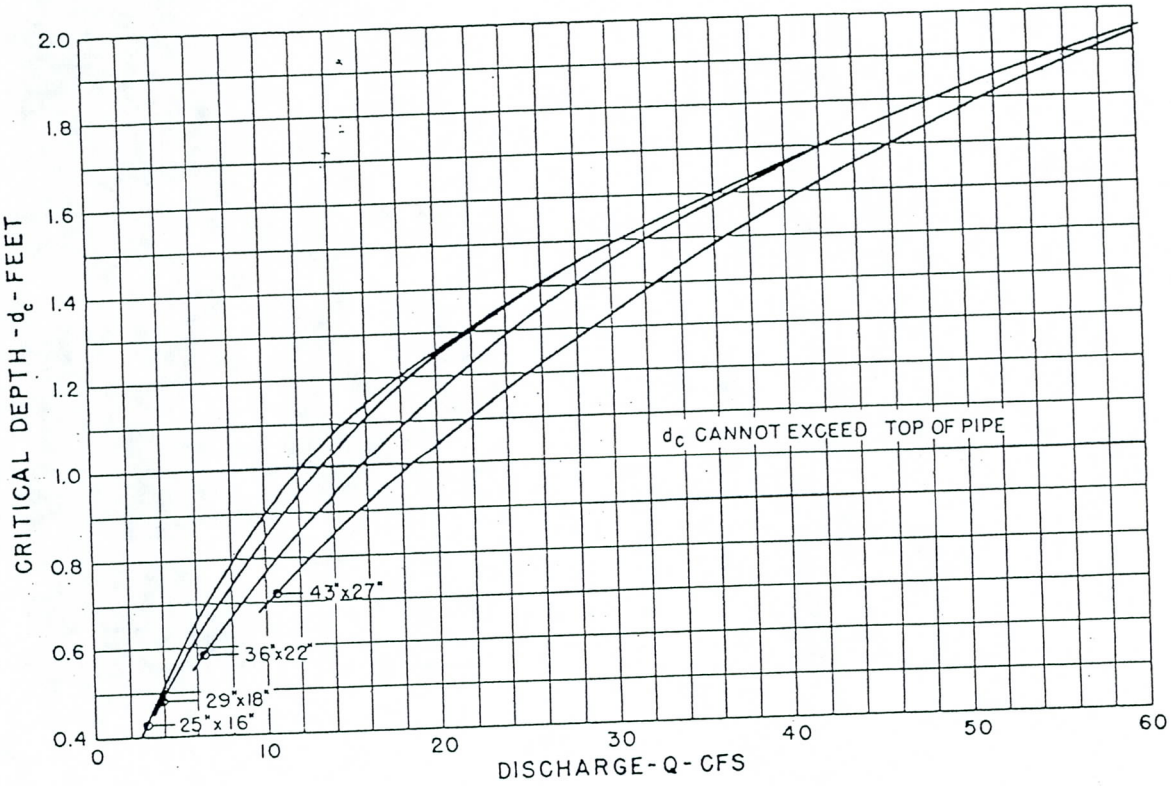


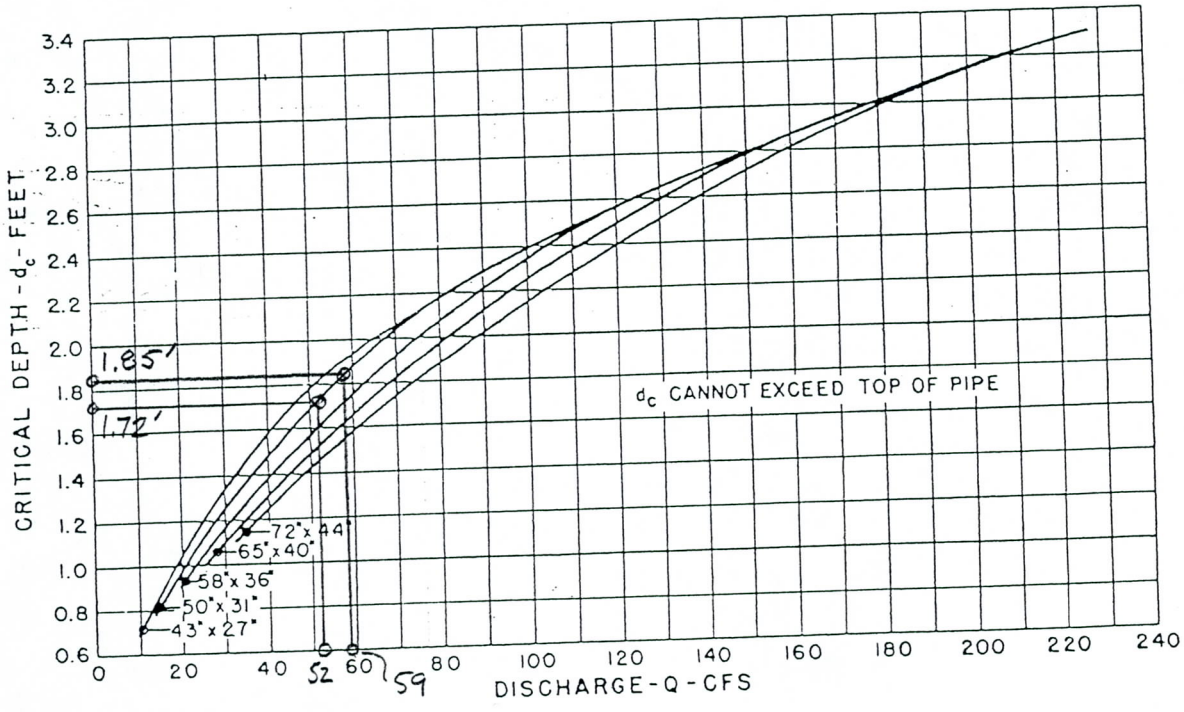
HEAD FOR
STANDARD C. M. PIPE-ARCH CULVERTS
FLOWING FULL
n=0.024

BUREAU OF PUBLIC ROADS JAN. 1963

Culvert No. 42

CHART 19





BUREAU OF PUBLIC ROADS

JAN. 1964

CRITICAL DEPTH
STANDARD C.M. PIPE-ARCH

SVERDRUP

JOB 40477 Toyota

COMPUTATIONS FOR Culvert No 42
Outlet Velocity

SHEET NO. ____ OF ____

DATE 9/9/91

BY BDO CHKD RJT

From CMP Arch Table 4-15

For a Full Pipe (49"x33")

Hydraulic Radius = 0.81 ft
Area = 8.90 ft²

Using Mannings Eqn. w/ S = 0.010%, & n = 0.024

$$Q = \frac{1.49}{.024}(8.9)(0.81)^{.666}(.01)^{.5} = 48.0 \text{ cfs}$$

(From Figure 4-38)

$$\frac{Q_P}{Q_{Full}} = \frac{59.0}{48.0} = 1.23 \quad \text{(Pipe Full)}$$

$$\therefore V = Q/A = 59/8.9 = \underline{6.63 \text{ fps}}$$

For

$$\frac{Q_P}{Q_{Full}} = \frac{52.0}{48.0} = 1.08 \Rightarrow \frac{A_P}{A_{Full}} = 0.95$$

$$V = \frac{Q}{A} = \frac{52}{0.95(8.9)} = \underline{6.15 \text{ fps}}$$

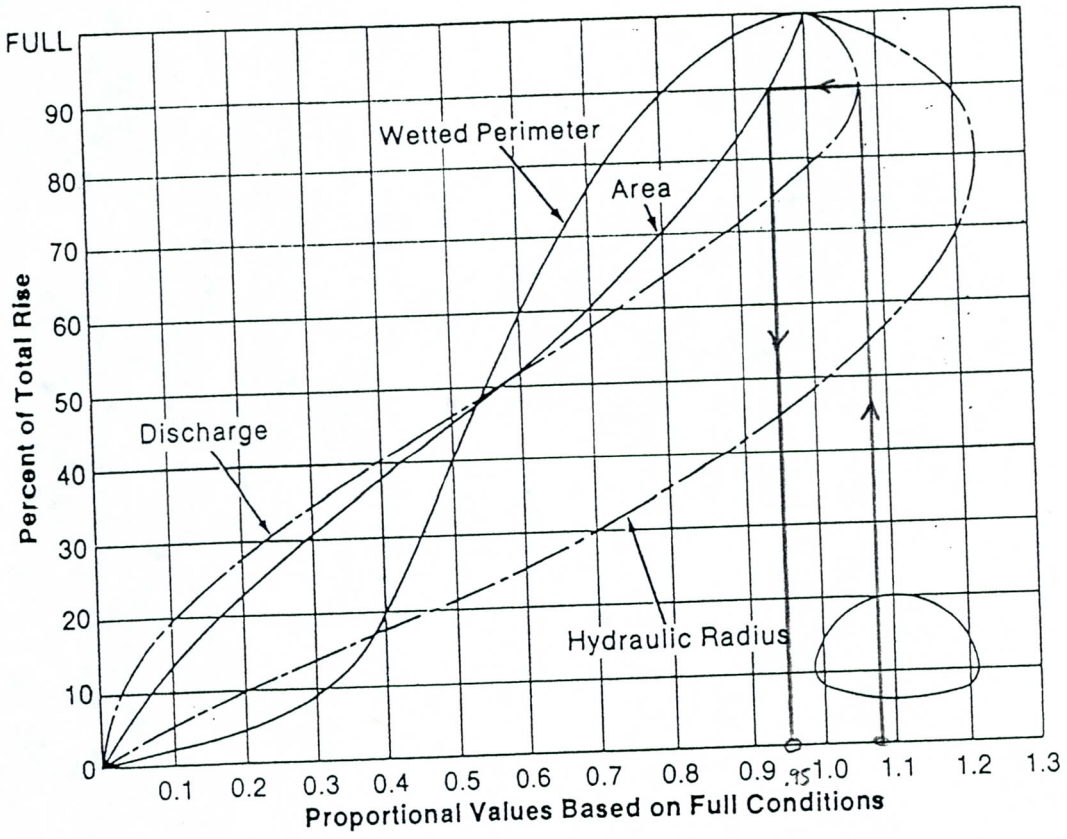


Figure 4-38 Hydraulic properties of corrugated steel and structural plate pipe-arches.

Table 4-15 Full-Flow Data for Corrugated Steel Pipe Arches

Corrugations 2⅔ × ½ in.					Corrugations 3 × 1 in. and 5 × 1 in.			
Dimensions, in.			Waterway Area, ft²	Hydraulic Radius A/πD, ft	Diameter, in.	Equiv. Size, in.	Waterway Area, ft²	Hydraulic Radius A/πD, ft
Pipe Diameter	Pipe-Arch Span	Pipe-Arch Rise						
15	17	13	1.1	0.280	54	60 × 46	15.6	1.104
18	21	15	1.6	0.340	60	66 × 51	19.3	1.230
21	24	18	2.2	0.400	66	73 × 55	23.2	1.343
24	28	20	2.9	0.462	72	81 × 59	27.4	1.454
30	35	24	4.5	0.573	78	87 × 63	32.1	1.573
36	42	29	6.5	0.69	84	95 × 67	37.0	1.683
*42	49	33	8.9	0.81	90	103 × 71	42.4	1.80
*48	57	38	11.6	0.924	96	112 × 75	48.0	1.911
*54	64	43	14.7	1.04	102	117 × 79	54.2	2.031
*60	71	47	18.1	1.153	108	128 × 83	60.5	2.141
*66	77	52	21.9	1.268	114	137 × 87	67.4	2.259
*72	83	57	26.0	1.38	120	142 × 91	74.5	2.373

SVERDRUP

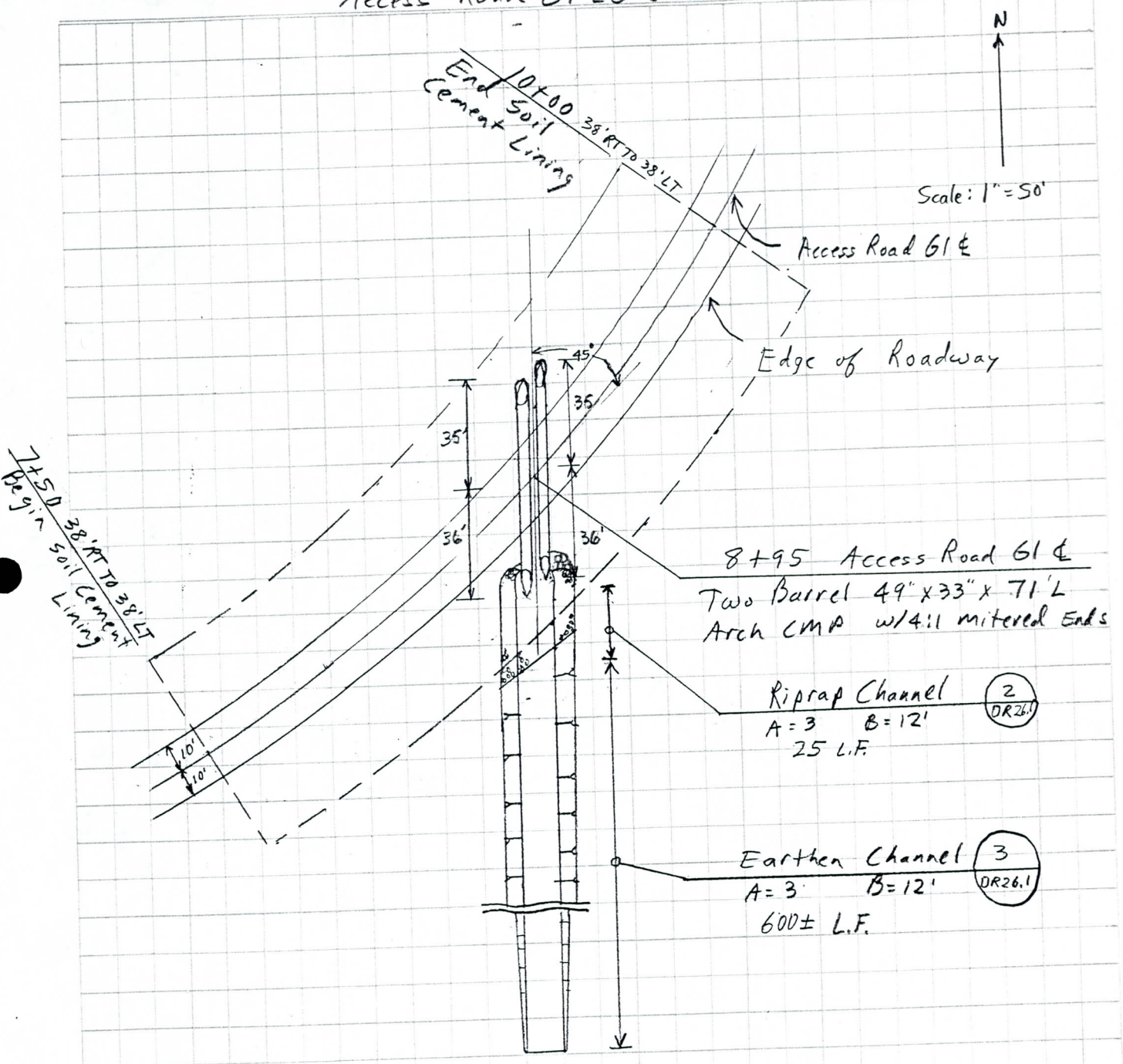
JOB 40477 Toyota

SHEET NO. _____ OF _____

DATE 9-8-91

COMPUTATIONS FOR Culvert 42 Plan View
Access Road G1 ℄ Sta 8+95

BY DFP CHKD RJT



42 Pipe Culvert Plan
Sta. 8+95 Access Road G1
See Profile Dwg. 14.1

SVERDRUP

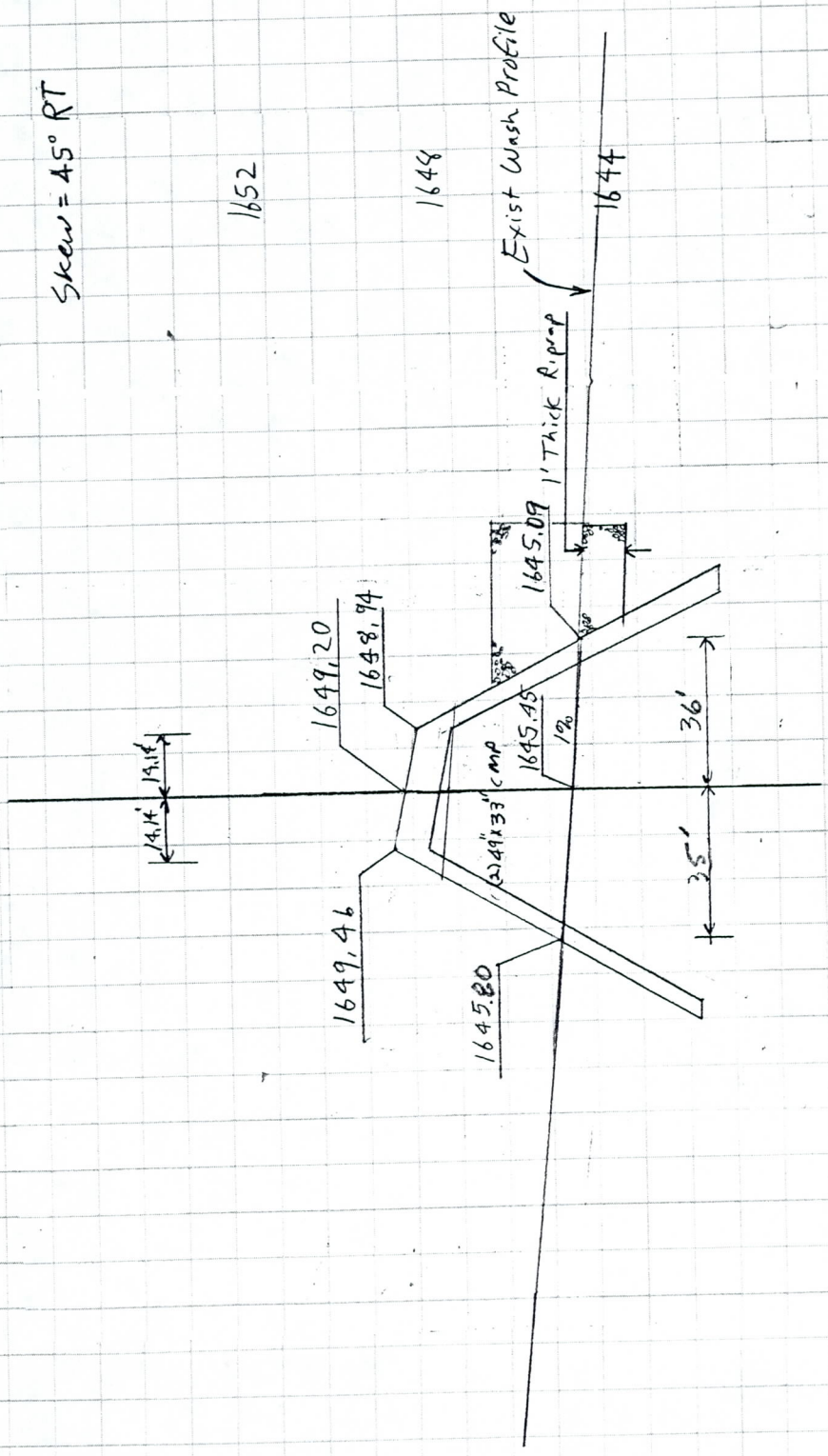
JOB 40477 Toyota

SHEET NO. _____ OF _____

DATE 9-10-91

COMPUTATIONS FOR Culvert 42 Profile
Access Road G1 & Sta 8+95

BY DFP CHKD RJT



Scale:
Horiz: 1" = 40'
Vert: 1" = 4'

42 Pipe Culvert Profile
Sta 8+95 Access Road G1
See Plan Dwg DR6.1

SECTION NUMBER G1 950 9/9/91

Channel Slope: 0.0118 ft./ft.

CROSS SECTION DATA:

OFFSET	400	900	925	950	975	1000	1300
ELEV.	50.93	49.18	49.15	49.27	49.52	49.9	55.3
N	N/A	0.025	0.025	0.025	0.025	0.025	0.025

STAGE-DISCHARGE DATA:

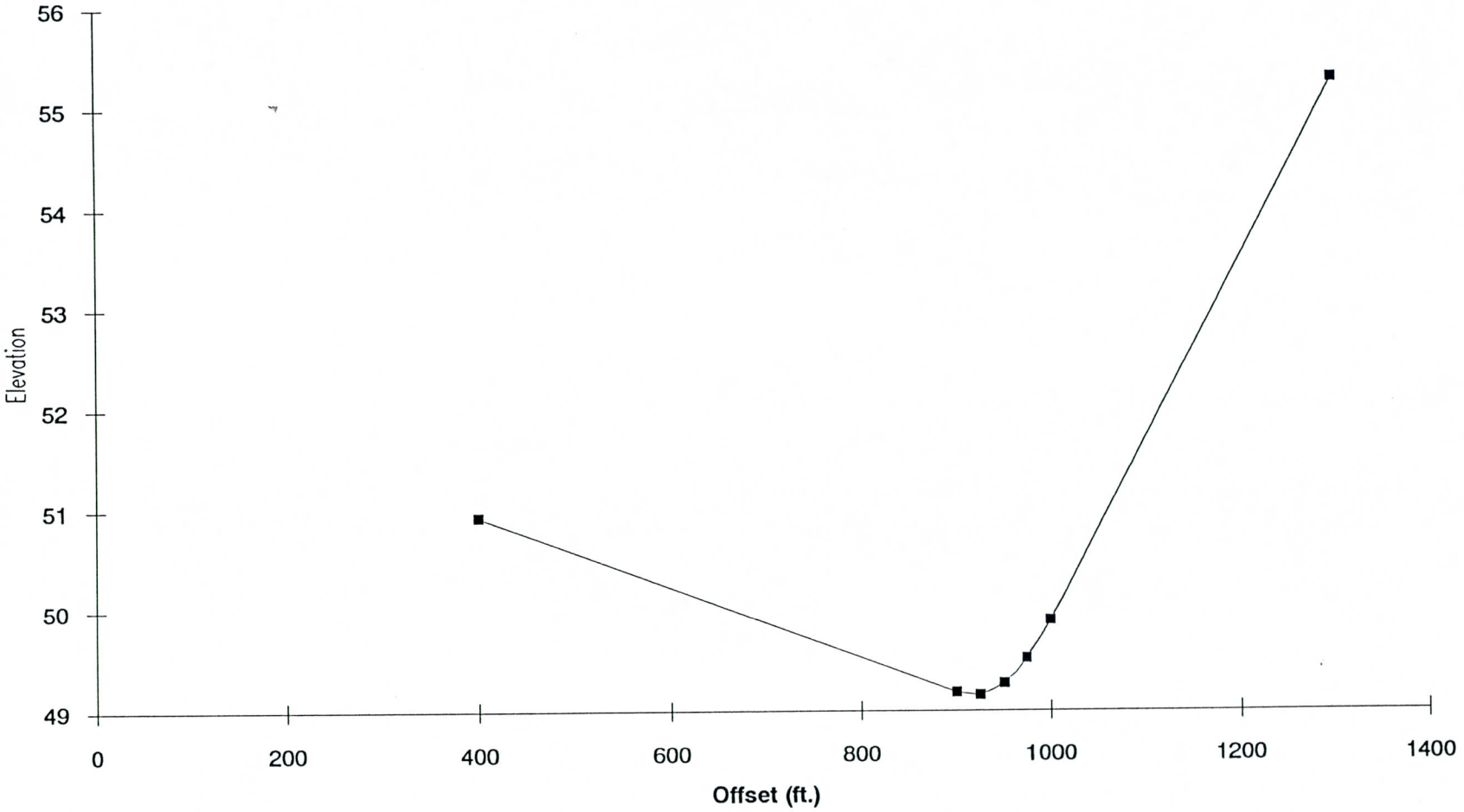
STAGE:	49.15										
WET PER.		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
AREA		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYD.RAD.		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Q		0	0	0	0	0	0	0	0	0	0	0
STAGE:	49.25										
WET PER.		20.0	45.0	65.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
AREA		0.7	2.8	3.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYD.RAD.		0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Q		0	0	4	0	0	0	0	0	0	0	0
STAGE:	49.35										
WET PER.		48.6	73.6	98.6	106.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0
AREA		4.1	8.8	12.3	12.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYD.RAD.		0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Q		0	0	0	20	0	0	0	0	0	0	0
STAGE:	49.45										
WET PER.		77.1	102.1	127.1	145.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
AREA		10.4	17.5	23.5	25.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYD.RAD.		0.1	0.2	0.2	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Q		0	0	0	51	0	0	0	0	0	0	0
STAGE:	49.55										
WET PER.		105.7	130.7	155.7	180.7	182.7	0.0	0.0	0.0	0.0	0.0	0.0
AREA		19.6	29.2	37.7	41.6	41.6	0.0	0.0	0.0	0.0	0.0	0.0
HYD.RAD.		0.2	0.2	0.2	0.2	0.2	0.0	0.0	0.0	0.0	0.0	0.0
Q		0	0	0	0	100	0	0	0	0	0	0
STAGE:	49.65										
WET PER.		134.3	159.3	184.3	209.3	217.8	0.0	0.0	0.0	0.0	0.0	0.0
AREA		31.6	43.7	54.7	61.1	61.6	0.0	0.0	0.0	0.0	0.0	0.0
HYD.RAD.		0.2	0.3	0.3	0.3	0.3	0.0	0.0	0.0	0.0	0.0	0.0
Q		0	0	0	0	171	0	0	0	0	0	0

SECTION NUMBER G1 950 9/9/91

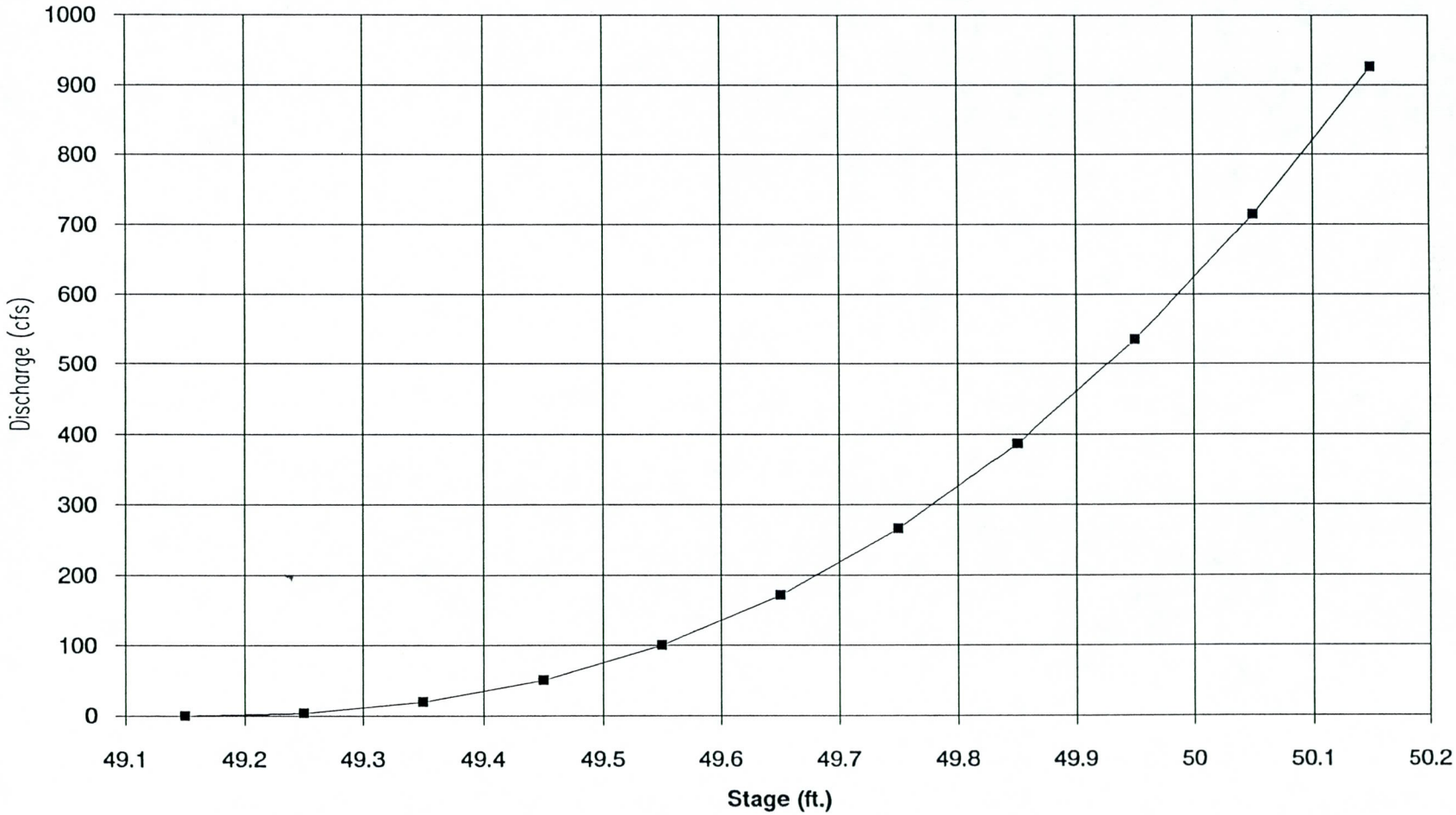
STAGE:	49.75										
WET PER.		162.9	187.9	212.9	237.9	253.0	0.0	0.0	0.0	0.0	0.0	0.0
AREA		46.4	61.0	74.5	83.4	85.2	0.0	0.0	0.0	0.0	0.0	0.0
HYD.RAD.		0.3	0.3	0.4	0.4	0.3	0.0	0.0	0.0	0.0	0.0	0.0
Q		0	0	0	0	266	0	0	0	0	0	0
STAGE:	49.85											
WET PER.		191.4	216.4	241.4	266.4	288.1	0.0	0.0	0.0	0.0	0.0	0.0
AREA		64.1	81.3	97.3	108.6	112.2	0.0	0.0	0.0	0.0	0.0	0.0
HYD.RAD.		0.3	0.4	0.4	0.4	0.4	0.0	0.0	0.0	0.0	0.0	0.0
Q		0	0	0	0	386	0	0	0	0	0	0
STAGE:	49.95											
WET PER.		220.0	245.0	270.0	295.0	320.0	322.8	0.0	0.0	0.0	0.0	0.0
AREA		84.7	104.3	122.8	136.7	142.7	142.8	0.0	0.0	0.0	0.0	0.0
HYD.RAD.		0.4	0.4	0.5	0.5	0.4	0.4	0.0	0.0	0.0	0.0	0.0
Q		0	0	0	0	0	535	0	0	0	0	0
STAGE:	50.05											
WET PER.		248.6	273.6	298.6	323.6	348.6	356.9	0.0	0.0	0.0	0.0	0.0
AREA		108.1	130.3	151.3	167.6	176.1	176.8	0.0	0.0	0.0	0.0	0.0
HYD.RAD.		0.4	0.5	0.5	0.5	0.5	0.5	0.0	0.0	0.0	0.0	0.0
Q		0	0	0	0	0	714	0	0	0	0	0
STAGE:	50.15											
WET PER.		277.1	302.1	327.1	352.1	377.1	391.0	0.0	0.0	0.0	0.0	0.0
AREA		134.4	159.0	182.5	201.4	212.4	214.2	0.0	0.0	0.0	0.0	0.0
HYD.RAD.		0.5	0.5	0.6	0.6	0.6	0.5	0.0	0.0	0.0	0.0	0.0
Q		0	0	0	0	0	926	0	0	0	0	0

W.S. Elev.	49.15	49.25	49.35	49.45	49.55	49.65	49.75	49.85	49.95	50.05	50.15
Q	0	4	20	51	100	171	266	386	535	714	926
A	0.0	3.9	12.6	25.2	41.6	61.6	85.2	112.2	142.8	176.8	214.2
V	0.0	1.0	1.6	2.0	2.4	2.8	3.1	3.4	3.7	4.0	4.3

Cross Section - G1 950



Stage Discharge - G1 950



SVERDRUP

JOB 40417 Toyota SHEET NO. ____ OF ____

COMPUTATIONS FOR Culvert No. 43 [43] DATE 9/6/91

BY BDO CHKD RTT

CULVERT COMPUTATION SHEET

PROJECT: ____ DESIGNER: ____

STATION: 16+10, Access Rd. E1 DATE: ____

HYDROLOGIC AND CHANNEL INFORMATION

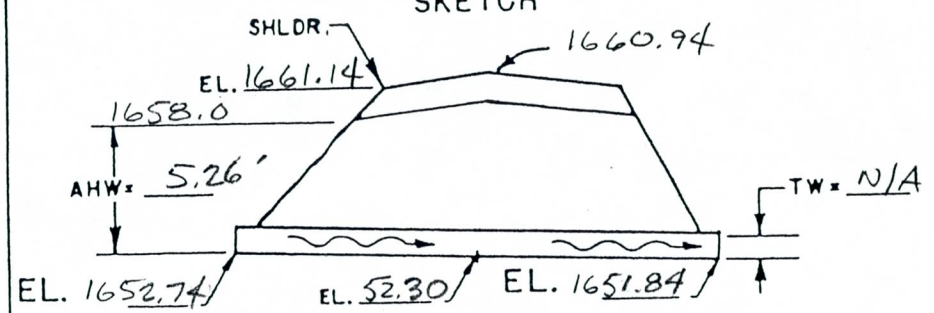
DRAINAGE AREA ____

Q_1 = 136 cfs TW_1 = N/A

Q_2 = ____ TW_2 = —

(Q_1 = DESIGN DISCHARGE, SAY Q_{25}; Q_2 = CHECK DISCHARGE, SAY Q_{50})

SKETCH



S_0 = 0.01% L = 90' L/100 S_0 = ____

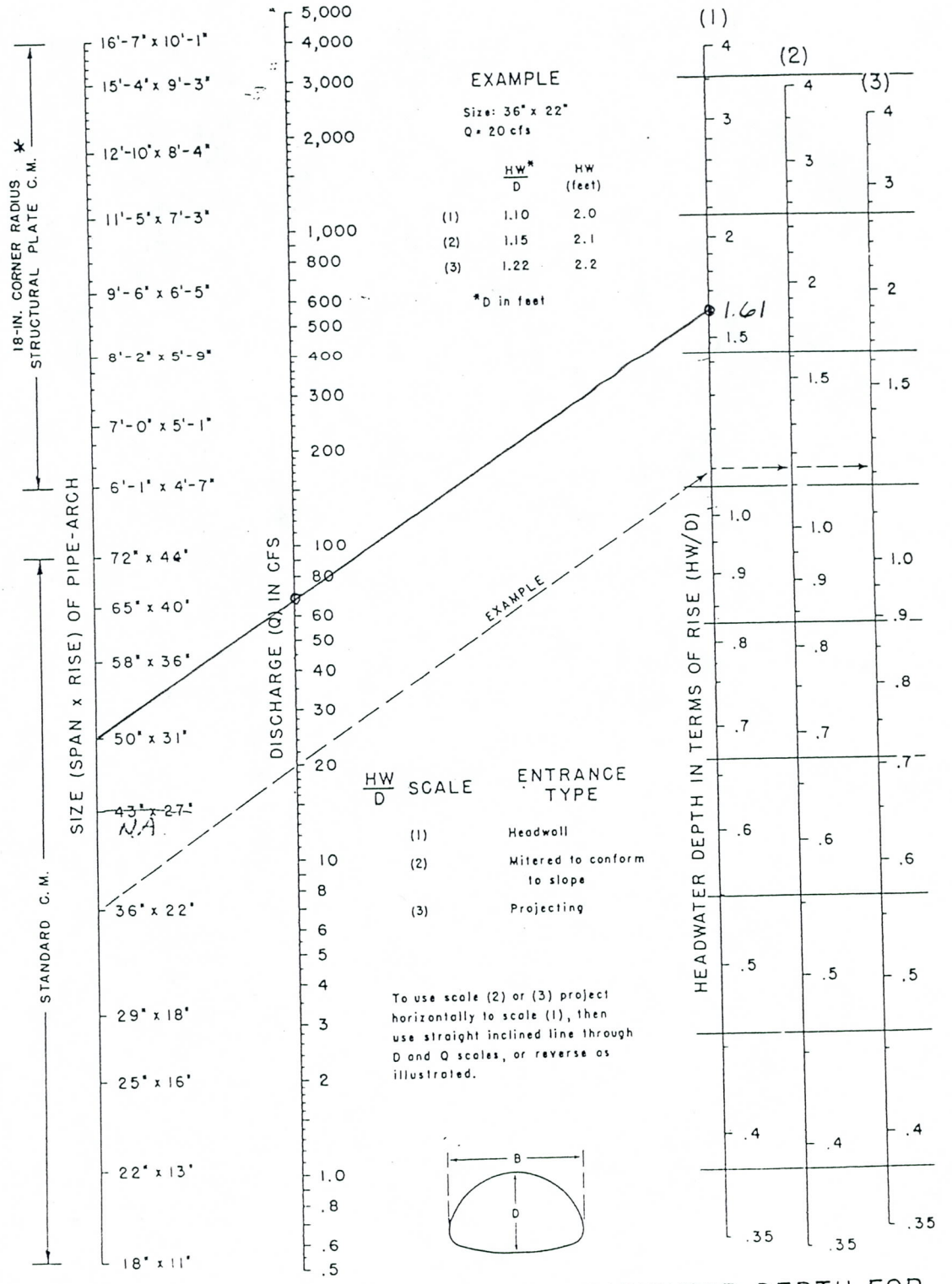
MEAN STREAM VELOCITY = —

CULVERT DESCRIPTION		Q	CAP. CHART HW	HEADWATER COMPUTATION										CONTROL HW	OUTLET VELOCITY	COST	DHW ELEV.	COMMENTS
				INLET CONT.		OUTLET CONTROL $HW = H + h_o - LS_o$												
SIZE	ENTR. TYPE			HW/D	HW	K_e	H	d_c	$\frac{d_c + D}{2}$	TW	h_o	LS_o	HW					
Cmp Arch (2)49"x33"	End Section	68		1.61	4.43'	0.5	3.50	2.0	2.38	—	2.38	0.90	4.98	4.98	9.2		1657.72	Outlet Control

SUMMARY & RECOMMENDATIONS Use dumped riprap downstream for erosion control.

Culvert No. 43

CHART 6



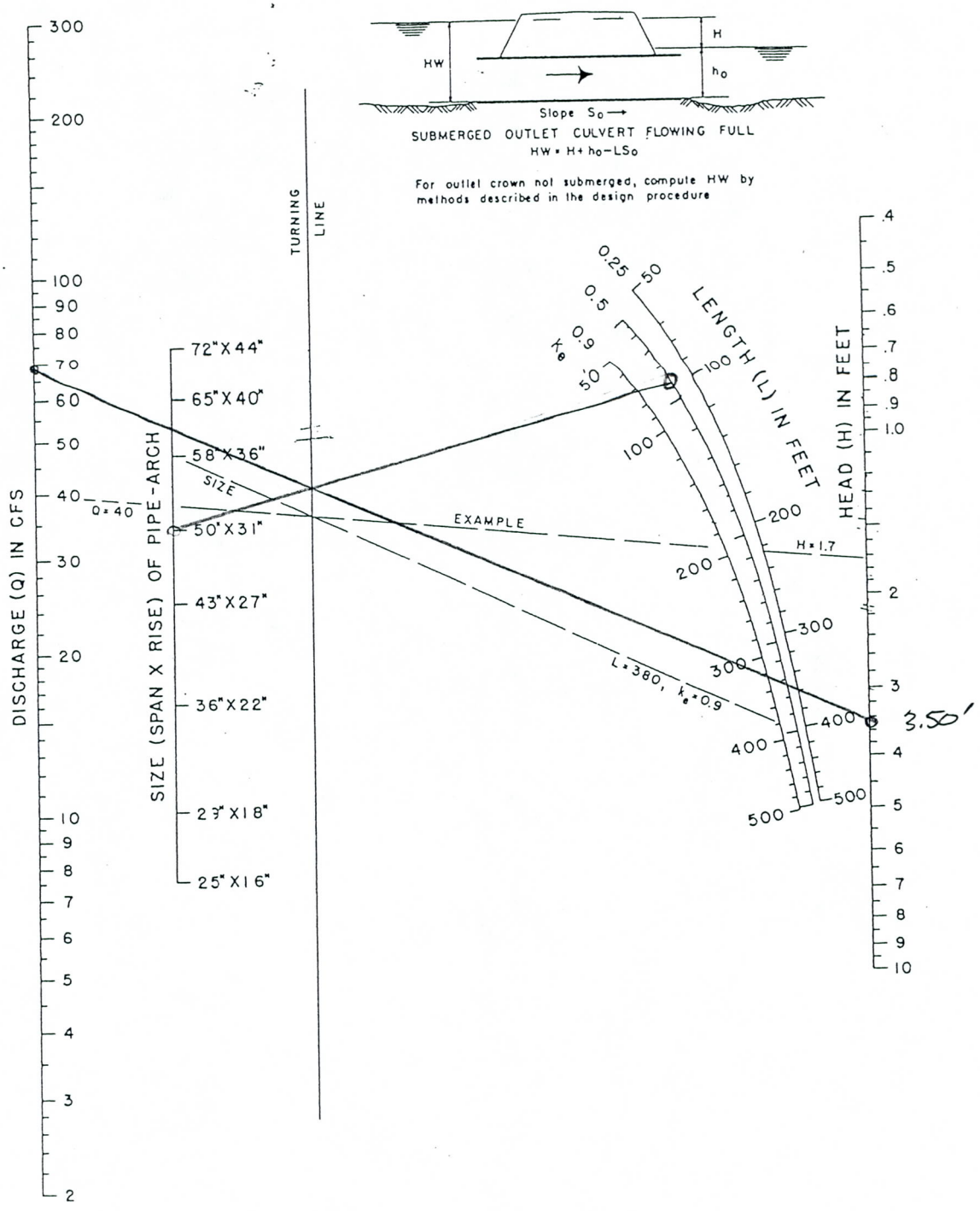
* ADDITIONAL SIZES NOT DIMENSIONED ARE LISTED IN FABRICATOR'S CATALOG

BUREAU OF PUBLIC ROADS JAN 1963

HEADWATER DEPTH FOR C. M. PIPE-ARCH CULVERTS WITH INLET CONTROL

Culvert No. 43

CHART 12

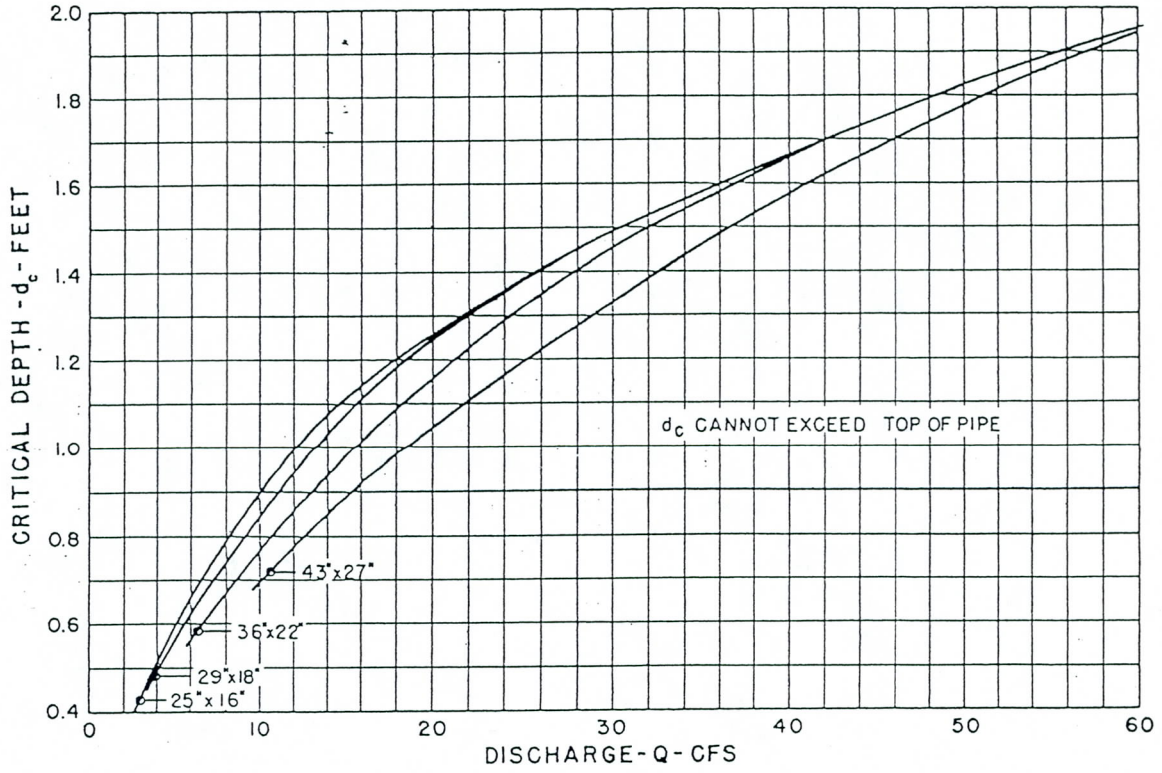


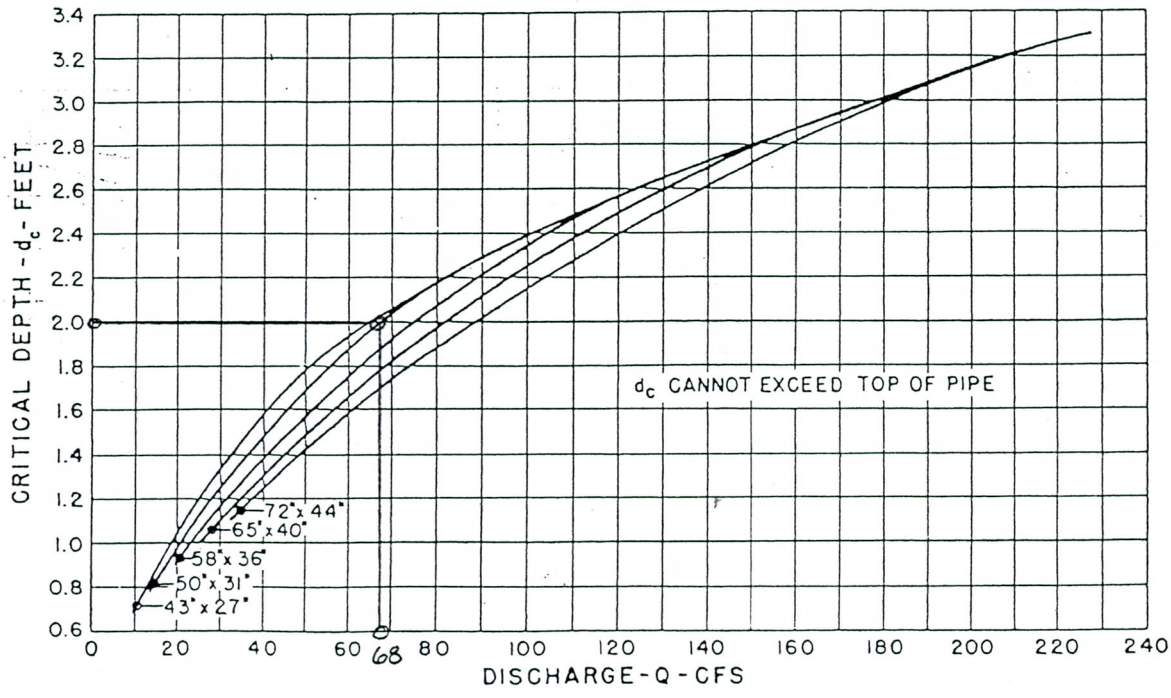
HEAD FOR
STANDARD C. M. PIPE-ARCH CULVERTS
FLOWING FULL
n=0.024

BUREAU OF PUBLIC ROADS JAN. 1963

Culvert No. 43

CHART 19





BUREAU OF PUBLIC ROADS

JAN. 1964

CRITICAL DEPTH
STANDARD C.M. PIPE-ARCH

SVERDRUP

JOB 40477 Toyota

SHEET NO. ____ OF ____

DATE 9/9/91

COMPUTATIONS FOR Culvert No. 43
Outlet Velocity

BY BDO CHKD RVT

From CMP Arch Table 4-15

For a Full Pipe (49" x 33")

Hydraulic Radius = 0.81 ft
Area = 8.90 ft²

Using Mannings Eqn. w/ S = 0.01%, n = 0.024

$$Q = \frac{1.49}{0.024}(8.9)(0.81)^{0.666}(0.01)^{.5} = 48.0 \text{ cfs}$$

With Outlet Control

$$D + (1+K_e)\frac{V^2}{2g} = 2.75 + (1+0.5)\frac{\left(\frac{68}{8.9}\right)^2}{64.4} = 4.11'$$

$d_c = 2.0'$ $HW = 4.98'$ $HW > 4.11'$ $TW < d_c < D$

∴ Culvert flows full for only part of its length

Velocity based upon area of flow at $d_c = 2.0'$

From Figure 4-38 w/ $\frac{2.0}{2.75} = 0.73 \Rightarrow \frac{A}{A_{Full}} = 0.83$

$$V = \frac{68}{0.83(8.9)} = 9.2 \text{ fps}$$

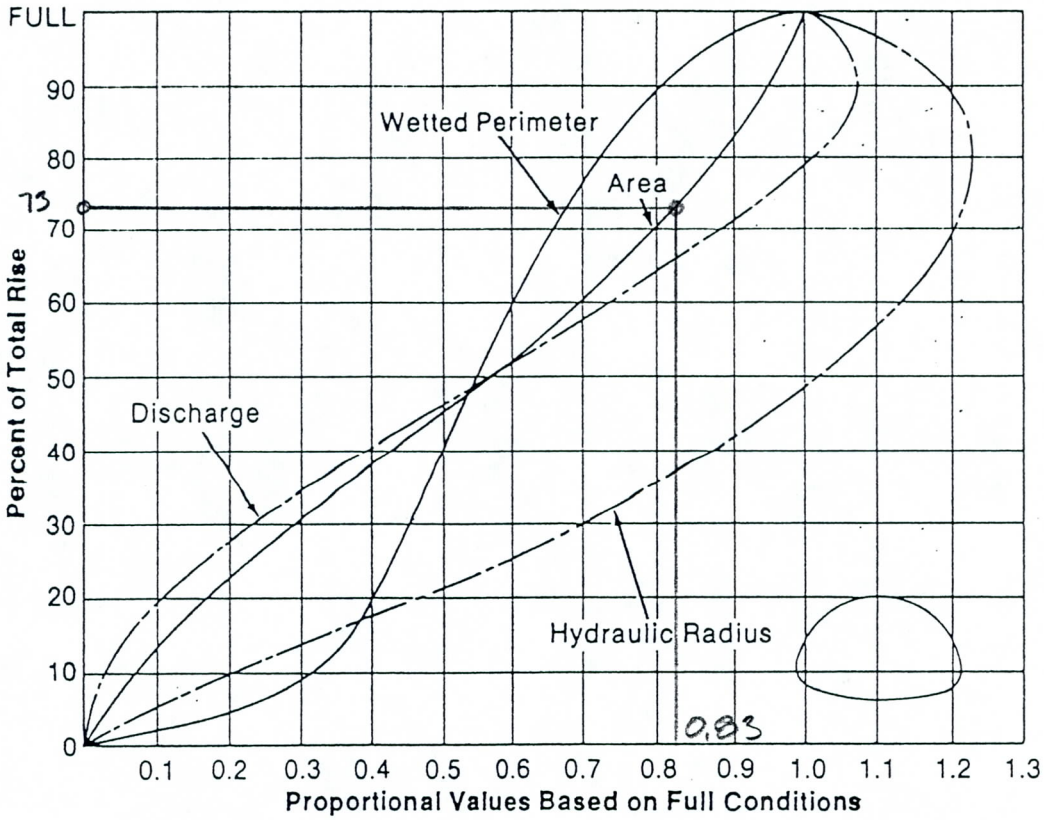


Figure 4-38 Hydraulic properties of corrugated steel and structural plate pipe-arches.

Table 4-15 Full-Flow Data for Corrugated Steel Pipe Arches

Corrugations 2⅔ × ½ in.					Corrugations 3 × 1 in. and 5 × 1 in.			
Dimensions, in.			Waterway Area, ft²	Hydraulic Radius A/πD, ft	Diameter, in.	Equiv. Size, in.	Waterway Area, ft²	Hydraulic Radius A/πD, ft
Pipe Diameter	Pipe-Arch Span	Pipe-Arch Rise						
15	17	13	1.1	0.280	54	60 × 46	15.6	1.104
18	21	15	1.6	0.340	60	66 × 51	19.3	1.230
21	24	18	2.2	0.400	66	73 × 55	23.2	1.343
24	28	20	2.9	0.462	72	81 × 59	27.4	1.454
30	35	24	4.5	0.573	78	87 × 63	32.1	1.573
36	42	29	6.5	0.69	84	95 × 67	37.0	1.683
→*42	49	33	8.9	0.81	90	103 × 71	42.4	1.80
*48	57	38	11.6	0.924	96	112 × 75	48.0	1.911
*54	64	43	14.7	1.04	102	117 × 79	54.2	2.031
*60	71	47	18.1	1.153	108	128 × 83	60.5	2.141
*66	77	52	21.9	1.268	114	137 × 87	67.4	2.259
*72	83	57	26.0	1.38	120	142 × 91	74.5	2.373

SVERDRUP

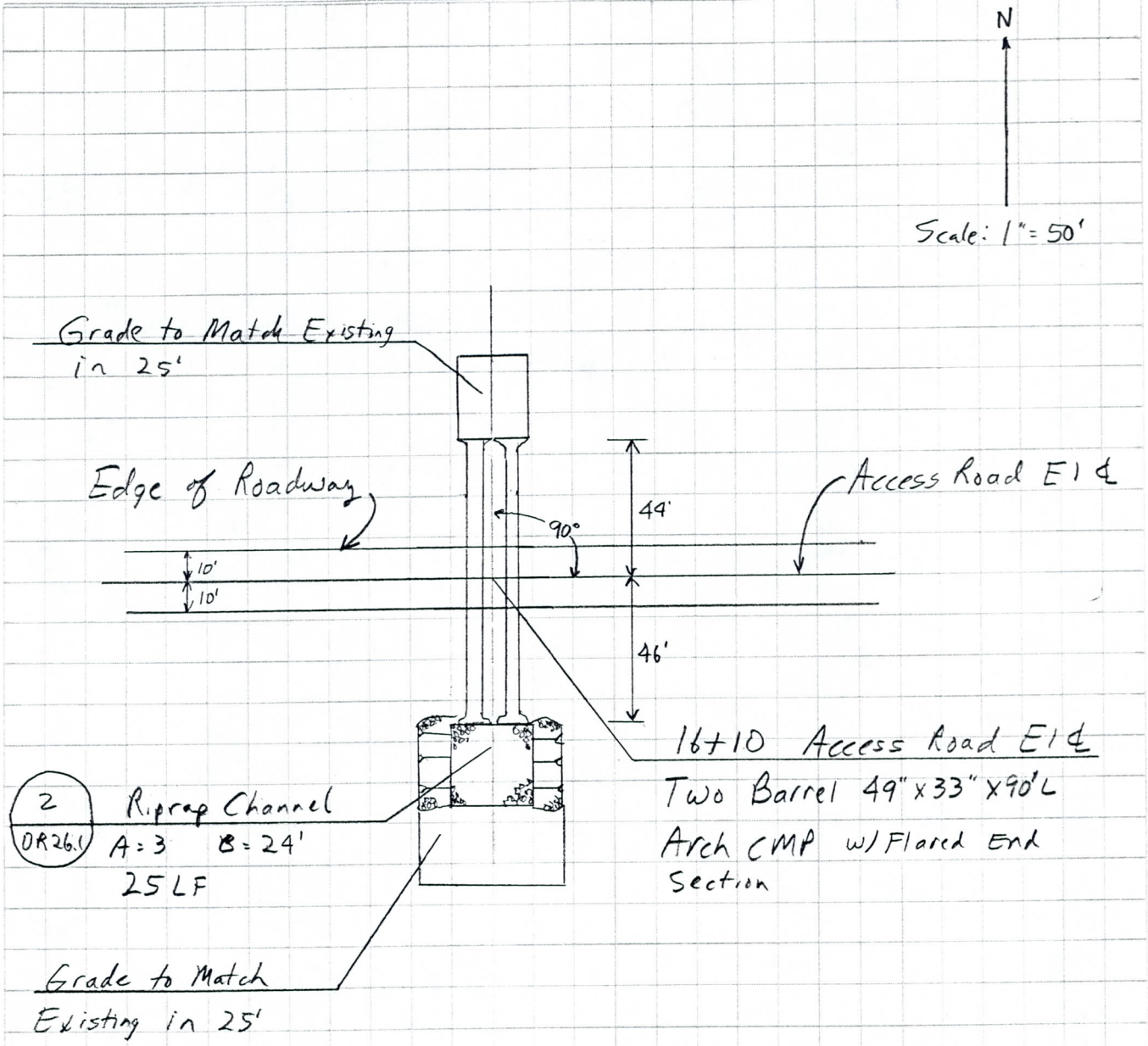
JOB 40477 Toyota

COMPUTATIONS FOR Culvert 43 Plan View
Access Road E1 Sta. 16+10

SHEET NO. _____ OF _____

DATE 9-8-91

BY DFP CHKD RJT



43 Pipe Culvert Plan
Sta 16+10 Access Road E1
See Profile DR 14.1

SVERDRUP

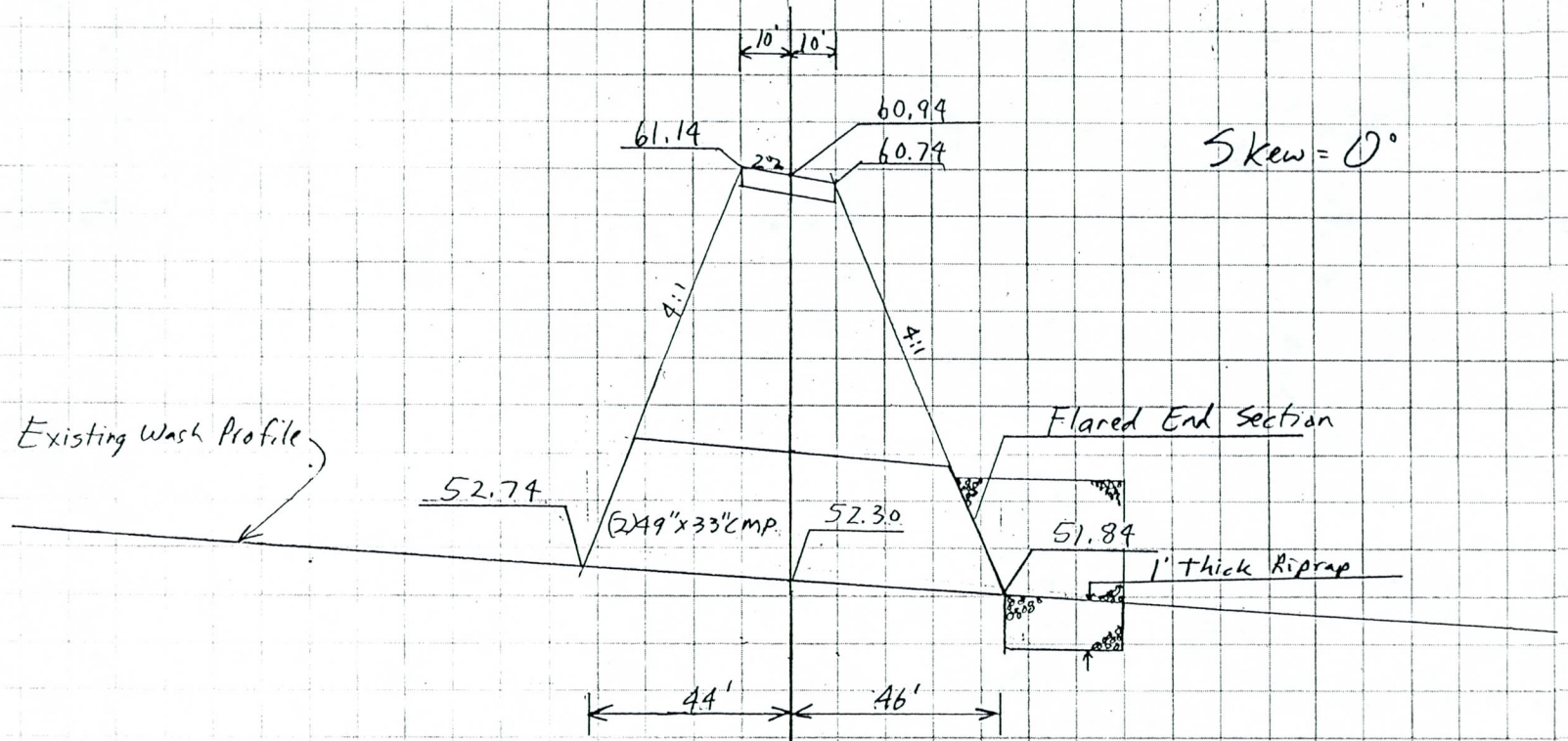
JOB 4077 Toyota

COMPUTATIONS FOR Culvert 43 Profile

SHEET NO. _____ OF _____

DATE 8-28-91

BY DEP CHKD RJT



Scale:
Horiz: 1" = 40'
Vert: 1" = 4'

Access Road E1
Sta 16+10
Pipe Culvert Profile

43

Sta. 16+10 Access Road E1
See Plan Dwg DR 6.1

SVERDRUP

JOB 4017 Toyota SHEET NO. ____ OF ____

COMPUTATIONS FOR Culvert No 44 [44] DATE 9/9/91

BY BDO CHKD RJT

CULVERT COMPUTATION SHEET

PROJECT: ____ DESIGNER: ____

STATION: Access Road El@Sta 25+00 DATE: ____

HYDROLOGIC AND CHANNEL INFORMATION

DRAINAGE AREA ____

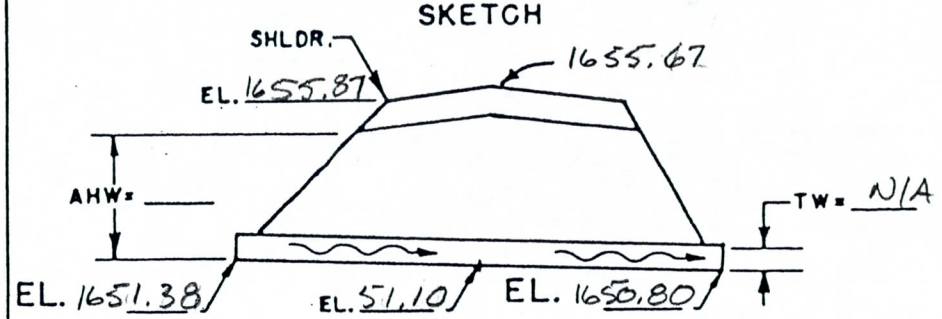
Q_1 = 486 *(0.5' water over road) TW_1 = N/A

Q_2 = 129 cfs (no water over road) TW_2 = N/A

* 350 cfs over roadway w/ 136 cfs through culverts

(Q_1 = DESIGN DISCHARGE, SAY Q_{25}; Q_2 = CHECK DISCHARGE, SAY Q_{50})

SKETCH



S_0 = 0.010' L = 58' L/100 S_0 = ____

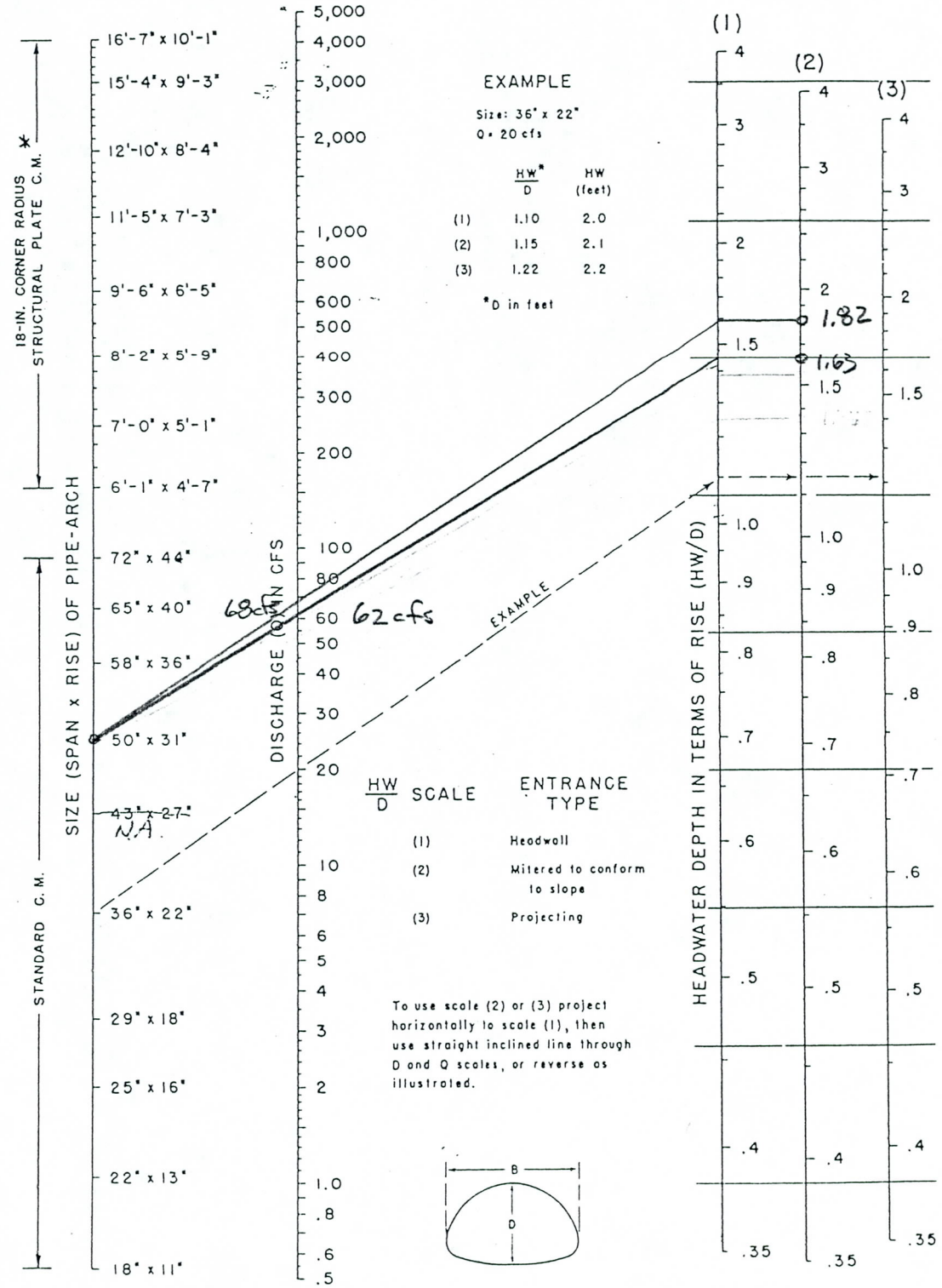
MEAN STREAM VELOCITY = N/A

CULVERT DESCRIPTION		Q	CAP. CHART HW	HEADWATER COMPUTATION										CONTROL HW	OUTLET VELOCITY	COST	DHW ELEV.	COMMENTS
				INLET CONT.		OUTLET CONTROL HW = H + h_o − LS_o												
SIZE	ENTR. TYPE			HW/D	HW	K_e	H	d_c	$\frac{d_c + D}{2}$	TW	h_o	LS_o	HW					
(2) CMPArch 49"x33"	mitered End	68		1.815	4.99	0.7	2.95	2.00	2.38	N/A	2.38	0.58	4.75	4.99	7.6		1656.37	Inlet Control
"	"	62		1.633	4.49	0.7	2.40	1.90	2.33	N/A	2.33	0.58	4.15	4.49	7.0		1655.87	Inlet Control

SUMMARY & RECOMMENDATIONS Use dumped riprap downstream of culvert for erosion protection. Soil cement embankment protection from Sta 23+50 to 25+50 for dip crossing.

Culvert No. 44

CHART 6



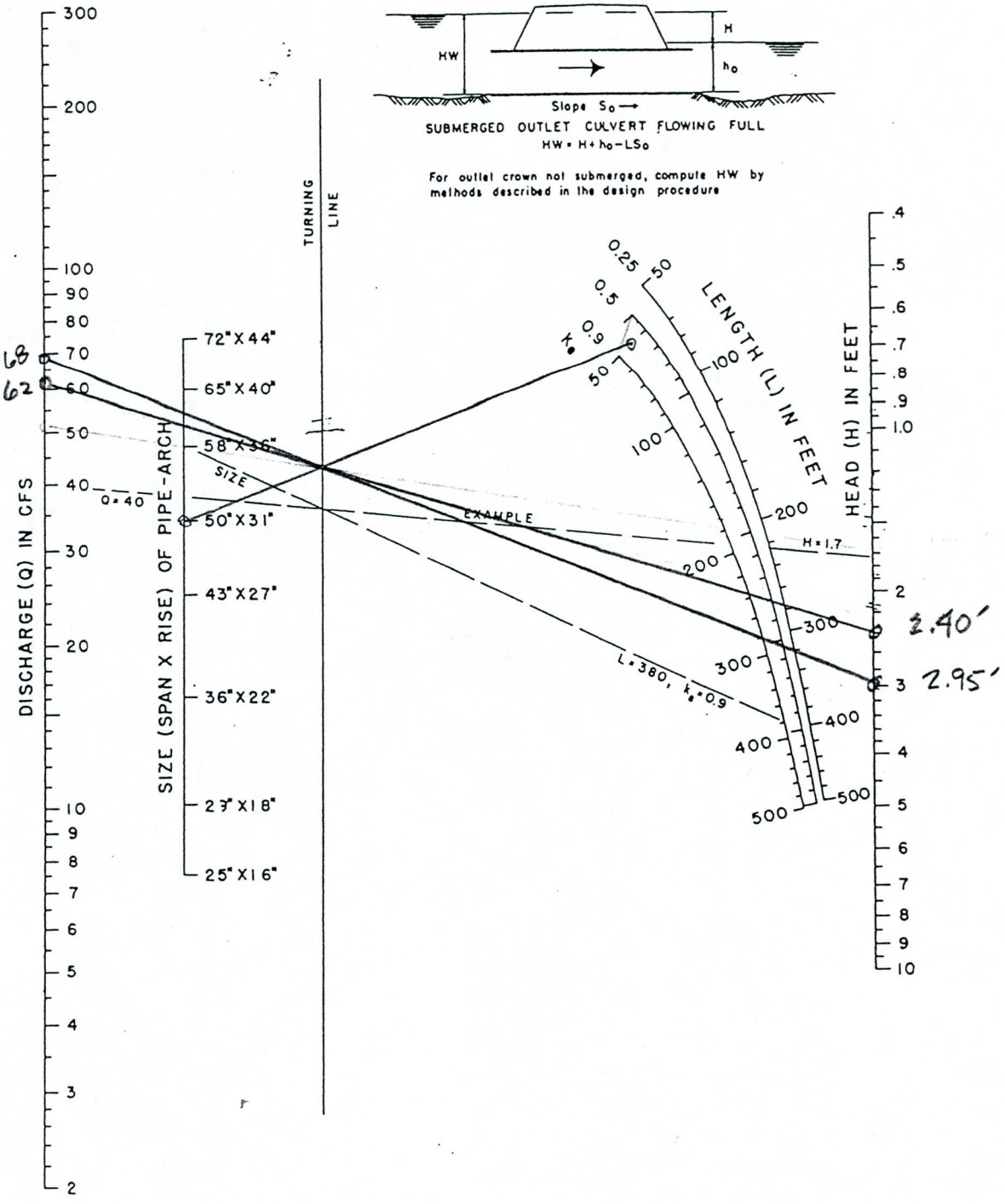
* ADDITIONAL SIZES NOT DIMENSIONED ARE LISTED IN FABRICATOR'S CATALOG

BUREAU OF PUBLIC ROADS JAN. 1963

HEADWATER DEPTH FOR C. M. PIPE-ARCH CULVERTS WITH INLET CONTROL

Culvert No. 44

CHART 12

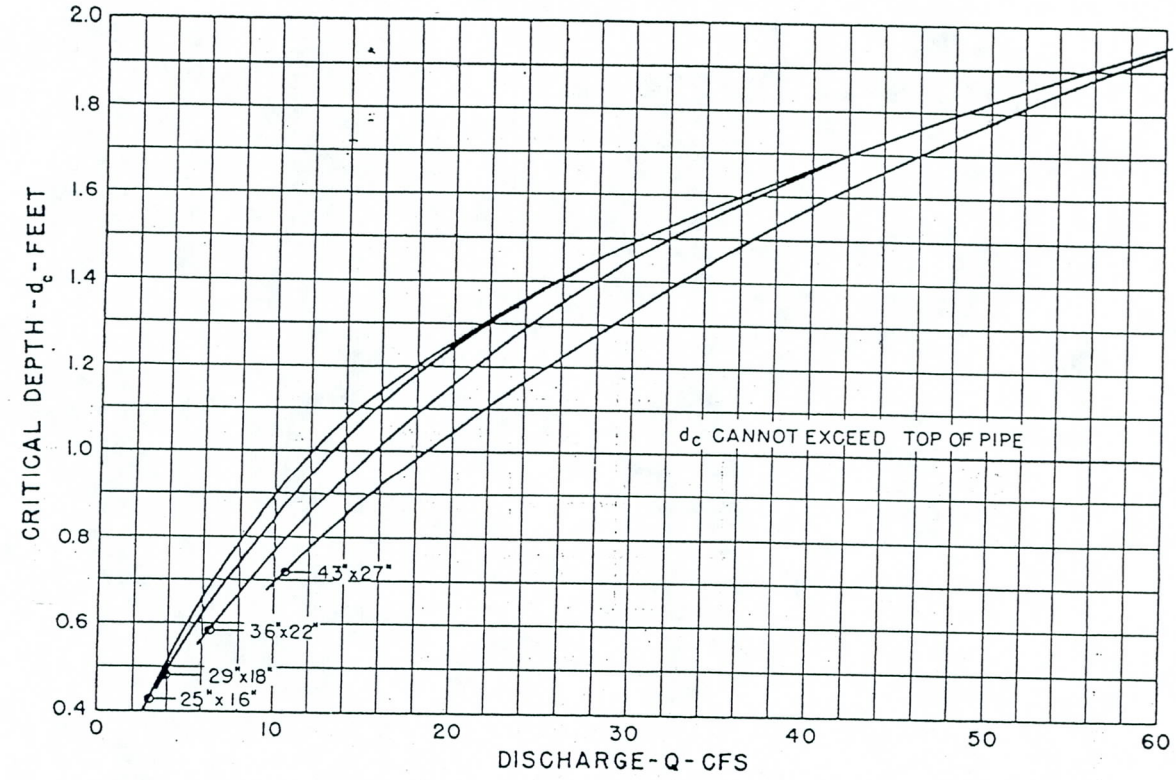


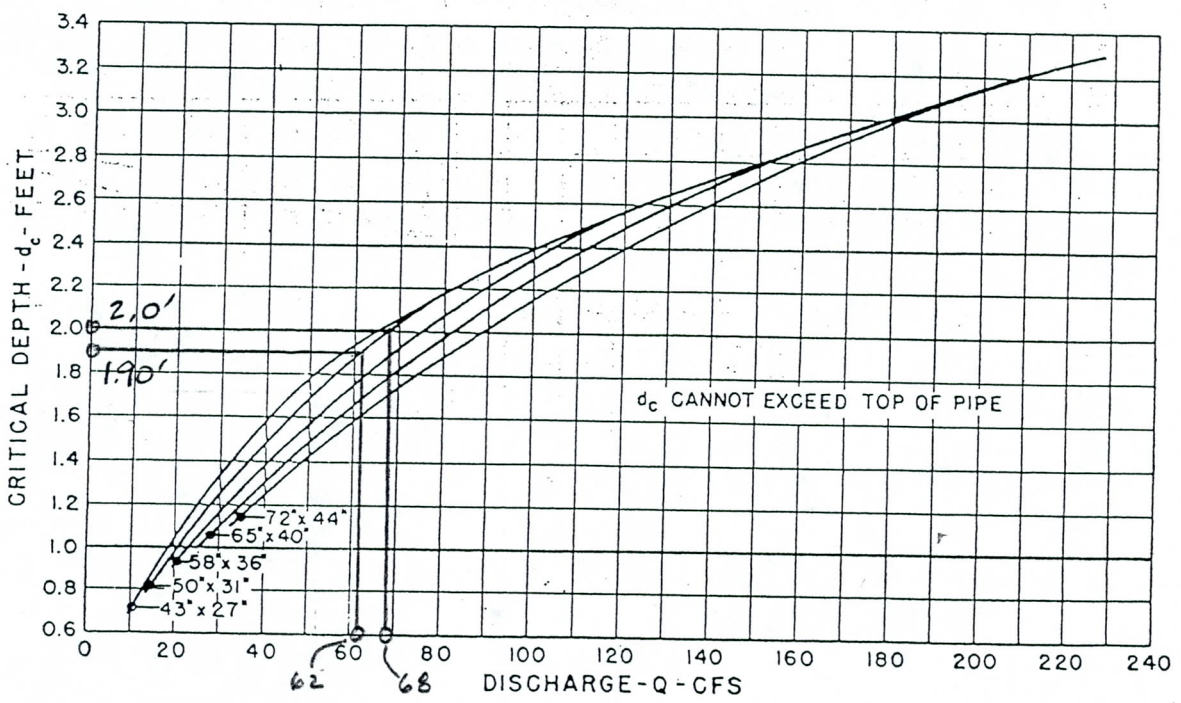
HEAD FOR
STANDARD C. M. PIPE-ARCH CULVERTS
FLOWING FULL
n=0.024

BUREAU OF PUBLIC ROADS JAN. 1963

Culvert No. 44

CHART 19





BUREAU OF PUBLIC ROADS

JAN. 1964

CRITICAL DEPTH
STANDARD C.M. PIPE-ARCH

SVERDRUP

JOB 40477 Toyota

SHEET NO. ____ OF ____

DATE 9/9/91

COMPUTATIONS FOR Culvert No 44
Outlet Velocity

BY BDO CHKD RJT

From CMP Arch Table 4-15

For a Full Pipe (49" x 33")

Hydraulic Radius = 0.81 ft
Area = 8.90 ft²

Using Mannings Eqn. w/ S = 0.010', n = 0.024

$$Q = \frac{1.49}{.024}(8.9)(0.81)^{.666}(.01)^{.5} = 48.0 \text{ cfs}$$

(From Figure 4-38)

$$\frac{Q_P}{Q_{Full}} = \frac{62}{48.0} = 1.29 \quad (\text{Pipe Full})$$

$$\therefore V = Q/A = 62/8.9 = \underline{6.97 \text{ fps}}$$

For

$$\frac{Q_P}{Q_{Full}} = \frac{68.0}{48.0} = 1.42 \quad (\text{Pipe Full})$$

$$V = Q/A = \frac{68}{8.9} = \underline{7.64 \text{ fps}}$$

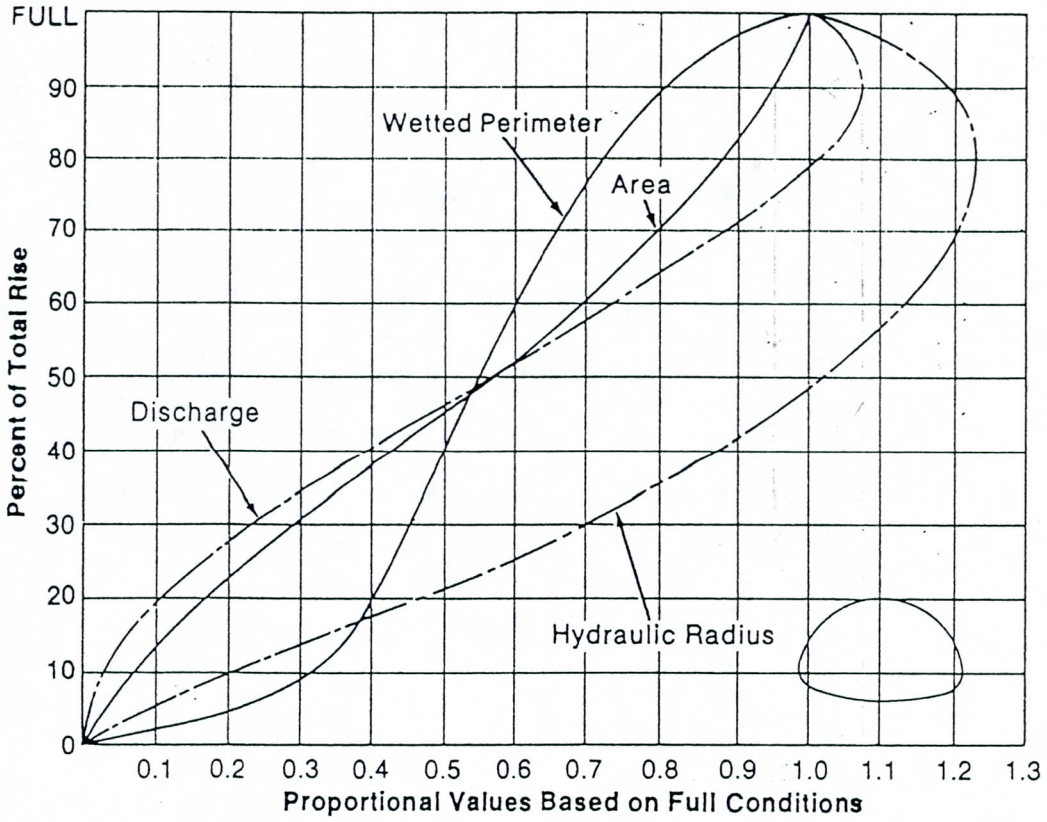


Figure 4-38 Hydraulic properties of corrugated steel and structural plate pipe-arches.

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Corrugations 2⅔ × ½ in.					Corrugations 3 × 1 in. and 5 × 1 in.			
Dimensions, in.			Waterway Area, ft²	Hydraulic Radius A/πD, ft	Diameter, in.	Equiv. Size, in.	Waterway Area, ft²	Hydraulic Radius A/πD, ft
Pipe Diameter	Pipe-Arch Span	Pipe-Arch Rise						
15	17	13	1.1	0.280	54	60 × 46	15.6	1.104
18	21	15	1.6	0.340	60	66 × 51	19.3	1.230
21	24	18	2.2	0.400	66	73 × 55	23.2	1.343
24	28	20	2.9	0.462	72	81 × 59	27.4	1.454
30	35	24	4.5	0.573	78	87 × 63	32.1	1.573
36	42	29	6.5	0.69	84	95 × 67	37.0	1.683
*42	49	33	8.9	0.81	90	103 × 71	42.4	1.80
*48	57	38	11.6	0.924	96	112 × 75	48.0	1.911
*54	64	43	14.7	1.04	102	117 × 79	54.2	2.031
*60	71	47	18.1	1.153	108	128 × 83	60.5	2.141
*66	77	52	21.9	1.268	114	137 × 87	67.4	2.259
*72	83	57	26.0	1.38	120	142 × 91	74.5	2.373

SVERDRUP

JOB 40477 Toyota

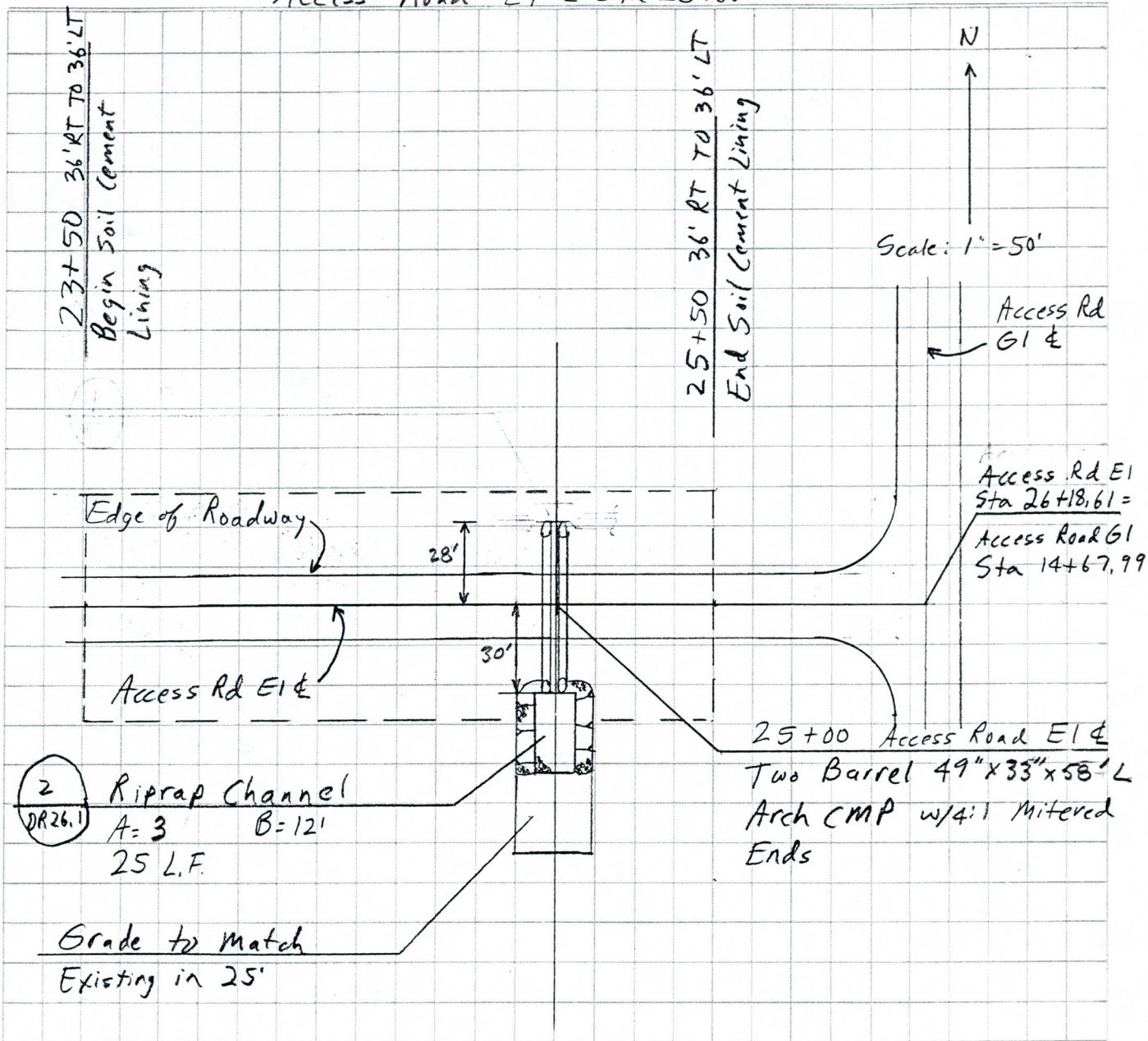
SHEET NO. _____ OF _____

DATE 9-8-91

COMPUTATIONS FOR Culvert 44 Plan View

BY DFP CHKD RJT

Access Road E1 & Sta 25+00



44 Pipe Culvert Plan

Sta 25+00 Access Road E1

See Profile Dwg. 14.1

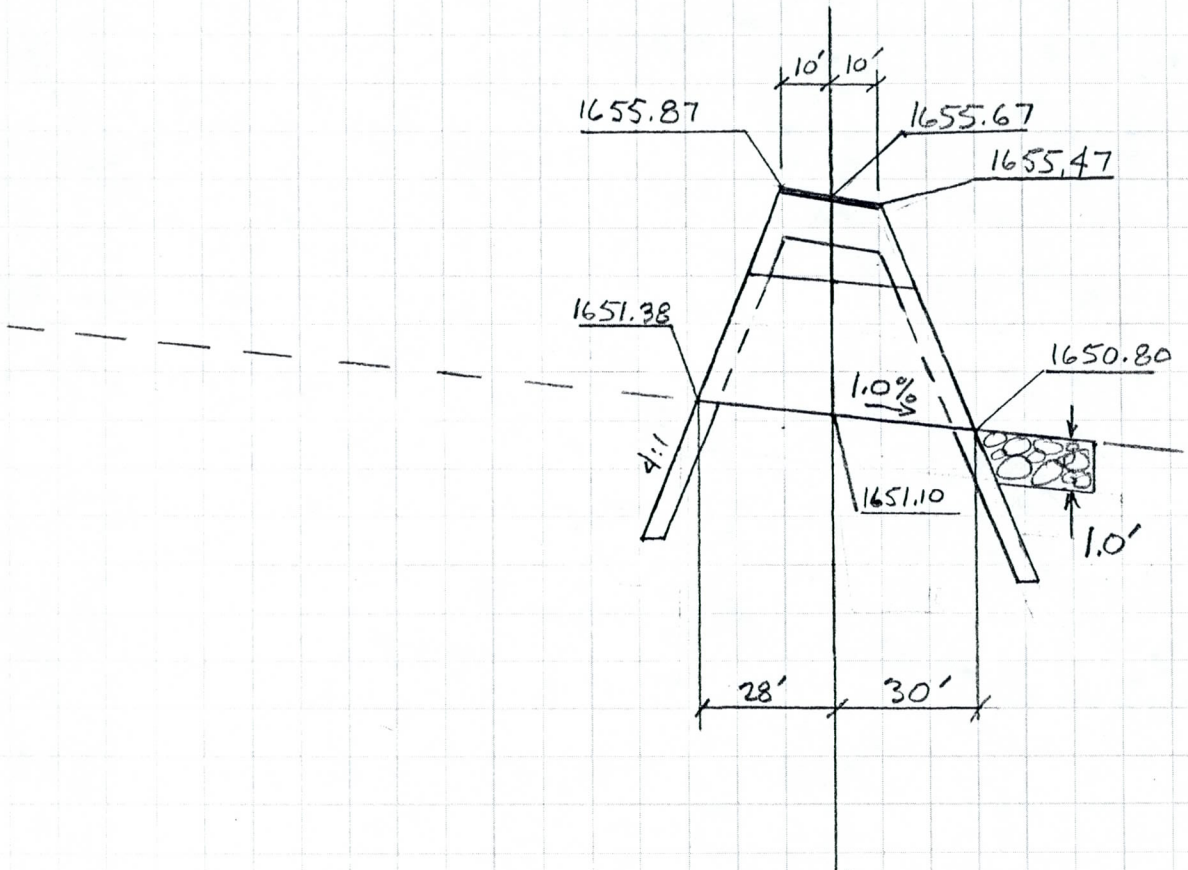
SVERDRUP

JOB 4047 Toyota SHEET NO. ____ OF ____

COMPUTATIONS FOR Culvert 44 Profile DATE 7/9/91

Access Rd E1 ℄ Sta 25+00 BY BDO CHKD RJT

Skew 0°



℄
Access Road E1
Sta 25+00

Scale
1" = 40' Horiz.
1" = 4' Vert.

44 Pipe Culvert Profile
Sta 25+00 Access Rd E1
See Plan DWG DR-6.1

SECTION NUMBER E12500 9/9/91

Channel Slope: 0.01 ft./ft.

CROSS SECTION DATA:

OFFSET	1900	2500	2525	2550	2575	2600	2611.1
ELEV.	56.3	55.67	55.71	55.88	56.19	56.63	56.85
N	N/A	0.025	0.025	0.025	0.025	0.025	0.025

STAGE-DISCHARGE DATA:

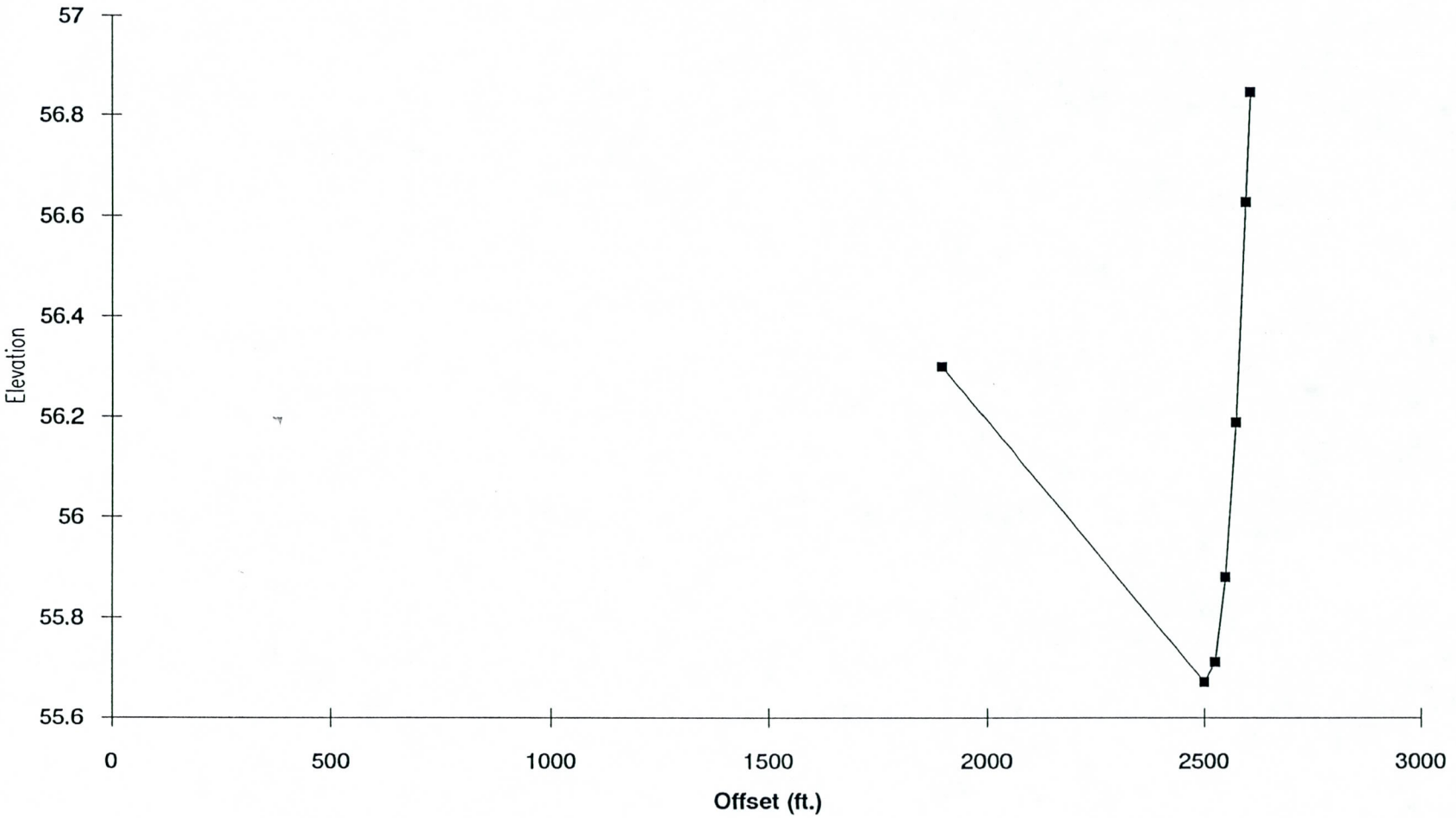
STAGE:	55.67										
WET PER.		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
AREA		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYD.RAD.		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Q		0	0	0	0	0	0	0	0	0	0	0
STAGE:	55.72										
WET PER.		47.6	72.6	74.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
AREA		1.2	1.9	1.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYD.RAD.		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Q		0	0	1	0	0	0	0	0	0	0	0
STAGE:	55.77										
WET PER.		95.2	120.2	129.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
AREA		4.8	6.8	7.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYD.RAD.		0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Q		0	0	6	0	0	0	0	0	0	0	0
STAGE:	55.82										
WET PER.		142.9	167.9	184.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
AREA		10.7	14.0	14.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYD.RAD.		0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Q		0	0	16	0	0	0	0	0	0	0	0
STAGE:	55.87										
WET PER.		190.5	215.5	239.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
AREA		19.0	23.5	25.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYD.RAD.		0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Q		0	0	34	0	0	0	0	0	0	0	0
STAGE:	55.92										
WET PER.		238.1	263.1	288.1	291.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
AREA		29.8	35.5	38.6	38.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYD.RAD.		0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Q		0	0	0	60	0	0	0	0	0	0	0

SECTION NUMBER E12500 9/9/91

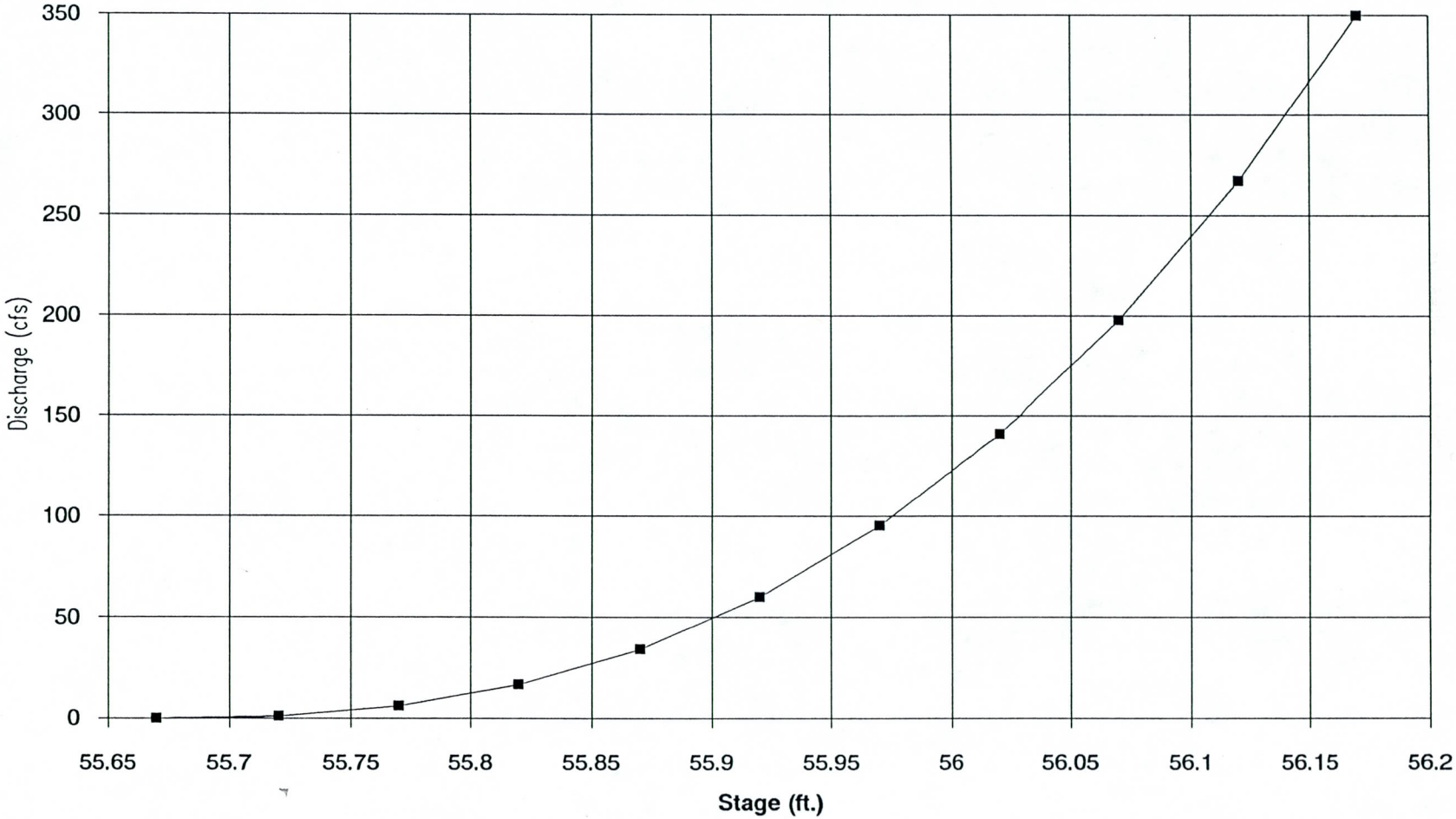
STAGE:	55.97										
WET PER.		285.7	310.7	335.7	343.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
AREA		42.9	49.9	54.2	54.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYD.RAD.		0.2	0.2	0.2	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Q		0	0	0	95	0	0	0	0	0	0	0
STAGE:	56.02											
WET PER.		333.3	358.3	383.3	394.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0
AREA		58.3	66.6	72.2	73.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYD.RAD.		0.2	0.2	0.2	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Q		0	0	0	141	0	0	0	0	0	0	0
STAGE:	56.07											
WET PER.		381.0	406.0	431.0	446.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
AREA		76.2	85.7	92.6	94.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYD.RAD.		0.2	0.2	0.2	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Q		0	0	0	198	0	0	0	0	0	0	0
STAGE:	56.12											
WET PER.		428.6	453.6	478.6	497.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0
AREA		96.4	107.2	115.3	117.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYD.RAD.		0.2	0.2	0.2	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Q		0	0	0	267	0	0	0	0	0	0	0
STAGE:	56.17											
WET PER.		476.2	501.2	526.2	549.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0
AREA		119.0	131.0	140.4	143.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYD.RAD.		0.3	0.3	0.3	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Q		0	0	0	350	0	0	0	0	0	0	0

W.S. Elev.	55.67	55.72	55.77	55.82	55.87	55.92	55.97	56.02	56.07	56.12	56.17
Q	0	1	6	16	34	60	95	141	198	267	350
A	0.0	1.9	7.0	14.9	25.4	38.7	54.6	73.0	94.0	117.6	143.8
V	0.0	0.5	0.9	1.1	1.3	1.5	1.7	1.9	2.1	2.3	2.4

Cross Section - E1 2500



Stage Discharge - E1 2500



SVERDRUP

JOB 40177 Toyota

COMPUTATIONS FOR Culvert No. 45 [45]

SHEET NO. ____ OF ____

DATE 9/1/91

BY BDO CHKD RJT

CULVERT COMPUTATION SHEET

PROJECT: ____

STATION: 1+00, Access Road A-2

DESIGNER: ____

DATE: ____

HYDROLOGIC AND CHANNEL INFORMATION

DRAINAGE AREA ____

Q_1 = 180* cfs (0.5' water over Road) TW_1 = 2.40'

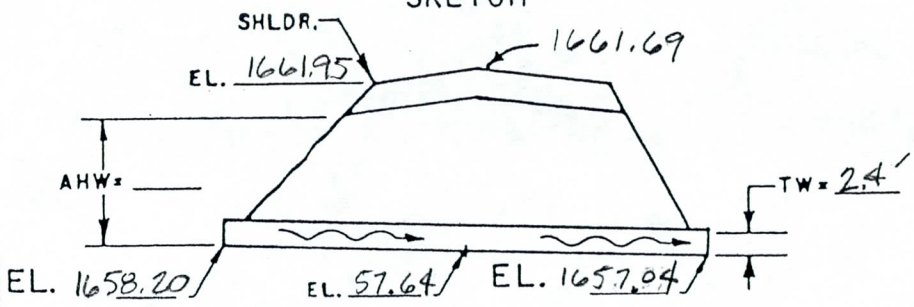
Q_2 = 54 cfs (no water over Road) TW_2 = 1.27'

* 120 cfs over roadway & 60 cfs through culvert

Low Flow Crossing

(Q_1 = DESIGN DISCHARGE, SAY Q_{25}; Q_2 = CHECK DISCHARGE, SAY Q_{50})

SKETCH



S_o = 0.02% L = 58' L/100 S_o = ____

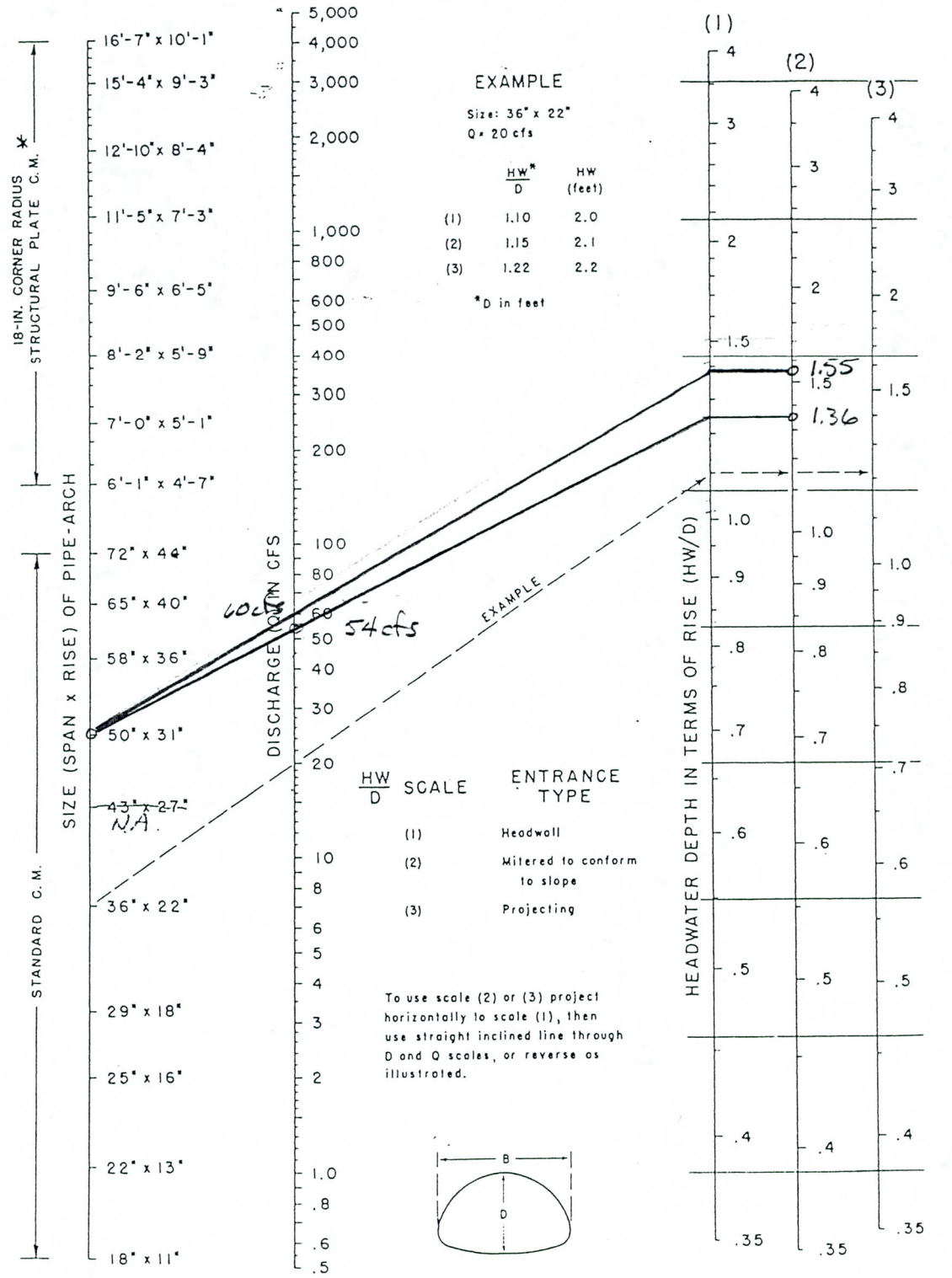
MEAN STREAM VELOCITY = 4.4 fps

	CULVERT DESCRIPTION		Q	CAP. CHART HW	HEADWATER COMPUTATION										CONTROL HW	OUTLET VELOCITY	COST	DHW ELEV.	COMMENTS
					INLET CONT.		OUTLET CONTROL $HW = H + h_o - LS_o$												
	SIZE	ENTR. TYPE			HW/D	HW	K_e	H	d_c	$\frac{d_c + D}{2}$	TW	H_o	LS_o	HW					
(1)	CMPArch 49"x33"	Drop Inlet w/ Mitered End	60cfs		1.55	4.25	0.7	2.35	1.87	2.31	2.40	2.40	1.16	3.59	4.25	8.5		1662.45	Inlet Control
	"	"	54cfs		1.36	3.75	0.7	1.90	1.75	2.25	1.27'	2.25	1.16	2.99	3.75	8.2		1661.95	Inlet Control

SUMMARY & RECOMMENDATIONS: Use dumped riprap downstream of culvert for erosion protection. Soil cement embankment protection from Sta 0+45 to 1+45 for dip crossing.

Culvert No. 45

CHART 6



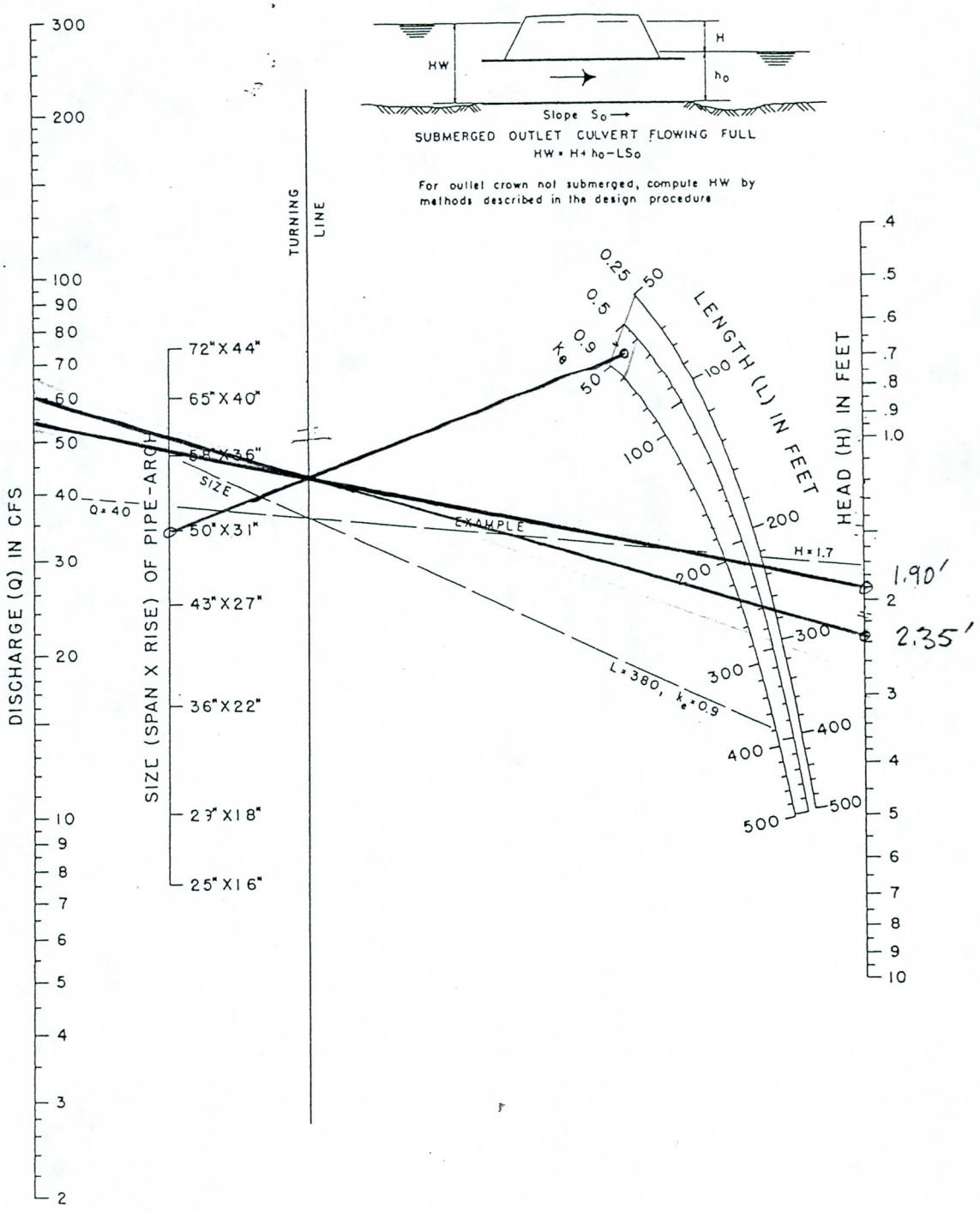
* ADDITIONAL SIZES NOT DIMENSIONED ARE LISTED IN FABRICATOR'S CATALOG

BUREAU OF PUBLIC ROADS JAN. 1963

HEADWATER DEPTH FOR C. M. PIPE-ARCH CULVERTS WITH INLET CONTROL

Culvert No. 45

CHART 12

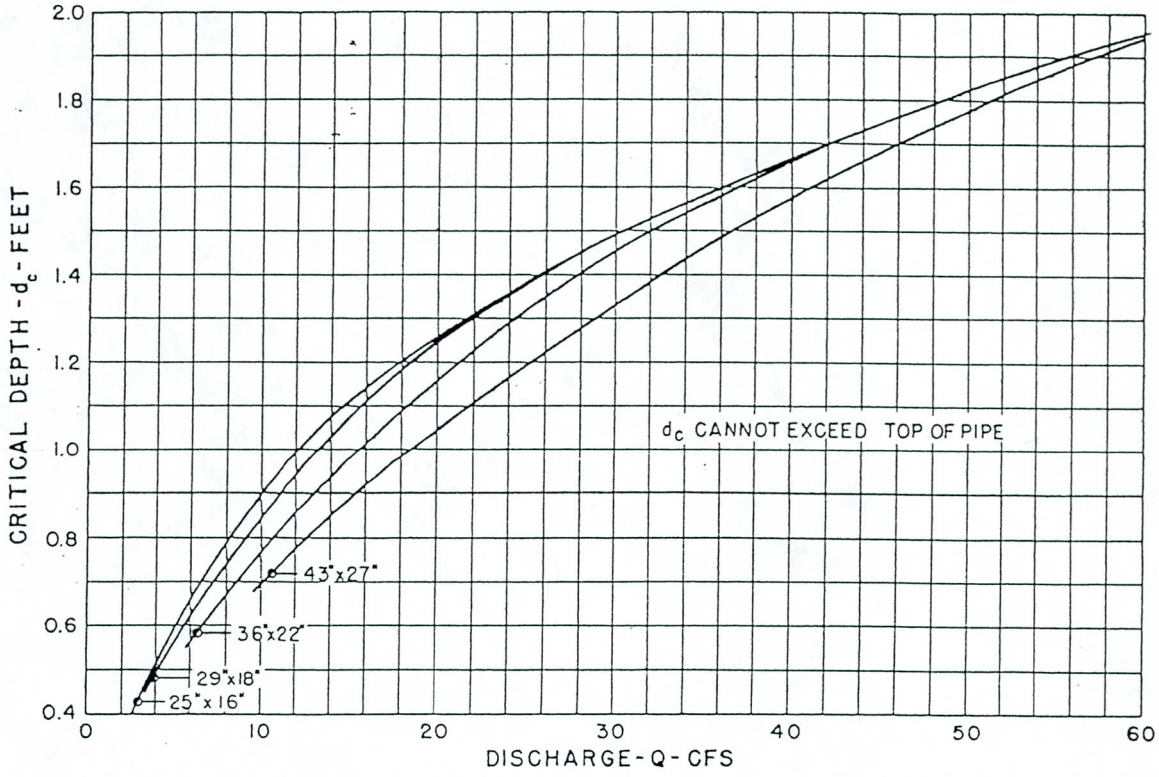


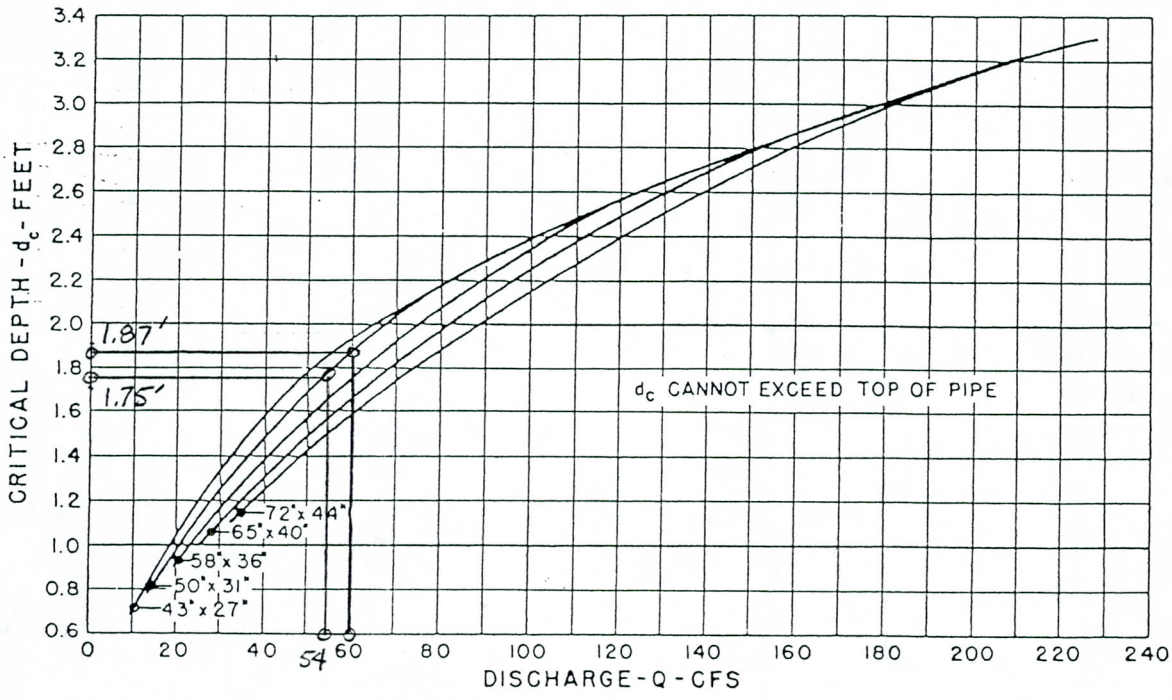
HEAD FOR
STANDARD C. M. PIPE-ARCH CULVERTS
FLOWING FULL
n=0.024

BUREAU OF PUBLIC ROADS JAN. 1963

Culvert No. 45

CHART 19





BUREAU OF PUBLIC ROADS

JAN. 1964

CRITICAL DEPTH
STANDARD C.M. PIPE-ARCH

SVERDRUP

JOB 40477 Toyota

SHEET NO. ____ OF ____

DATE 9/9/91

COMPUTATIONS FOR Culvert No 45
Outlet Velocity

BY BDO CHKD RJT

From CMP Arch Pipe Table 4-15

For a Full Pipe (49"x33")

Hydraulic Radius = 0.81 ft
Area = 8.90 ft²

Using Manning's Eqn. w/ S = 0.02 ft/ft, n = 0.024

$$Q = \frac{1.49}{.024}(8.9)(0.81)^{.666}(0.02)^{0.5} = 67.9 \text{ cfs}$$

(From Figure 4-38)

$$\frac{Q_P}{Q_{Full}} = \frac{54}{67.9} = 0.80 \Rightarrow \frac{A}{A_{Full}} = 0.74$$

$$V = \frac{Q}{A} = \frac{54}{0.74(8.9)} = 8.2 \text{ fps}$$

For

$$\frac{Q_P}{Q_{Full}} = \frac{60}{67.9} = 0.88 \Rightarrow \frac{A}{A_{Full}} = 0.79$$

$$V = \frac{Q}{A} = \frac{60}{0.79(8.9)} = 8.5 \text{ fps}$$

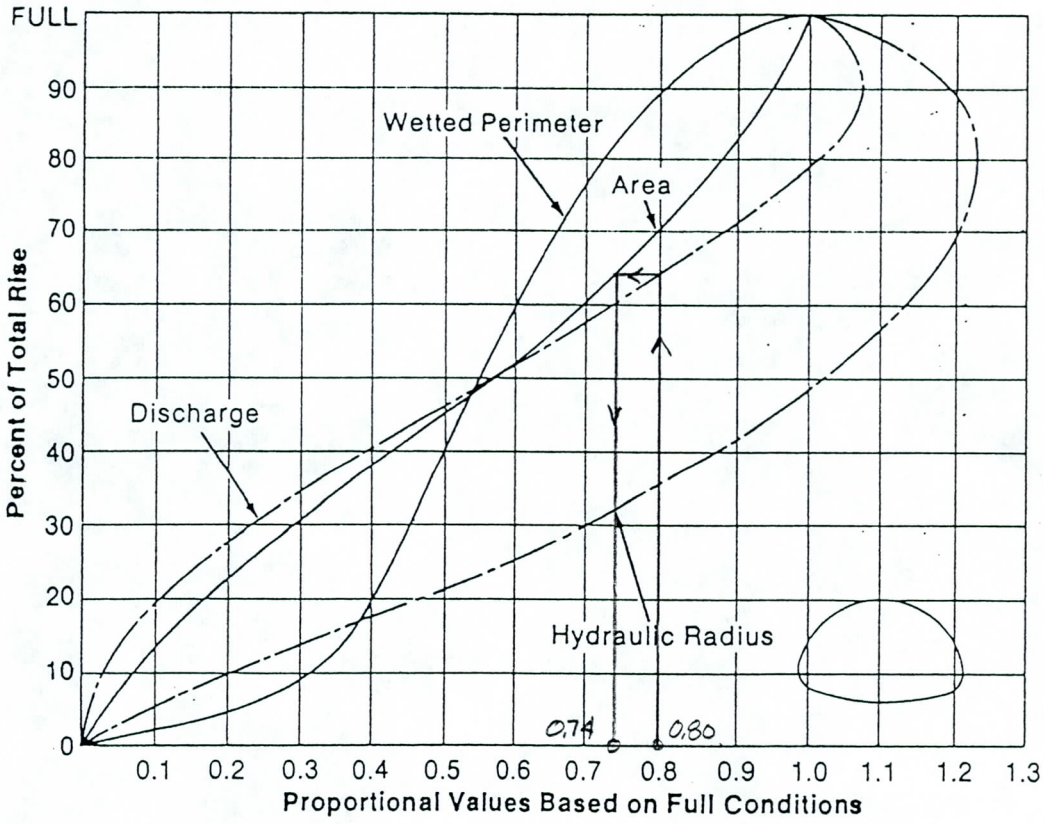


Figure 4-38 Hydraulic properties of corrugated steel and structural plate pipe-arches.

Table 4-15 Full-Flow Data for Corrugated Steel Pipe Arches

Corrugations 2⅔ × ½ in.					Corrugations 3 × 1 in. and 5 × 1 in.			
Dimensions, in.			Waterway Area, ft²	Hydraulic Radius A/πD, ft	Diameter, in.	Equiv. Size, in.	Waterway Area, ft²	Hydraulic Radius A/πD, ft
Pipe Diameter	Pipe-Arch Span	Pipe-Arch Rise						
15	17	13	1.1	0.280	54	60 × 46	15.6	1.104
18	21	15	1.6	0.340	60	66 × 51	19.3	1.230
21	24	18	2.2	0.400	66	73 × 55	23.2	1.343
24	28	20	2.9	0.462	72	81 × 59	27.4	1.454
30	35	24	4.5	0.573	78	87 × 63	32.1	1.573
36	42	29	6.5	0.69	84	95 × 67	37.0	1.683
*42	49	33	8.9	0.81	90	103 × 71	42.4	1.80
*48	57	38	11.6	0.924	96	112 × 75	48.0	1.911
*54	64	43	14.7	1.04	102	117 × 79	54.2	2.031
*60	71	47	18.1	1.153	108	128 × 83	60.5	2.141
*66	77	52	21.9	1.268	114	137 × 87	67.4	2.259
*72	83	57	26.0	1.38	120	142 × 91	74.5	2.373

SVERDRUP

JOB 40477 Toyota SHEET NO. ____ OF ____

DATE 9/2/91

COMPUTATIONS FOR Channel Section Downstream of Culvert No. 45 BY BDO CHKD RJT

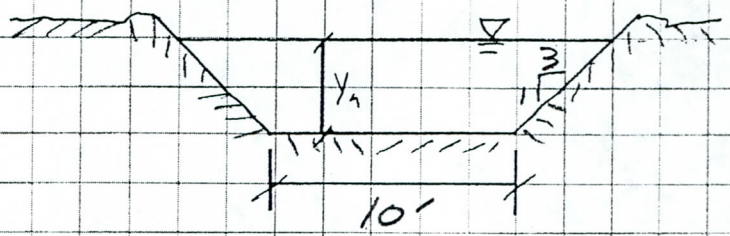
Check depth of flow using Mannings Eqn.

$Q = 180$ cfs

$n = 0.03$

$S_o = 0.0040$ ft/ft

$Y_n \sim 2.40'$



$A = 41.29$ ft^2

$WP = 2(7.59) + 10 = 25.18$ ft

$R_h = A/WP = 41.29/25.18 = 1.6398$ ft

$$V = \frac{1.49}{.03}(1.6398)^{.666}(.0040)^{.5} = 4.37 \text{ fps}$$

Check

$Q = VA = 4.37\,(41.29) = 180$ cfs

For $Q = 54$ cfs

$Y_n = 1.27'$ $V = 3.08$ fps

SVERDRUP

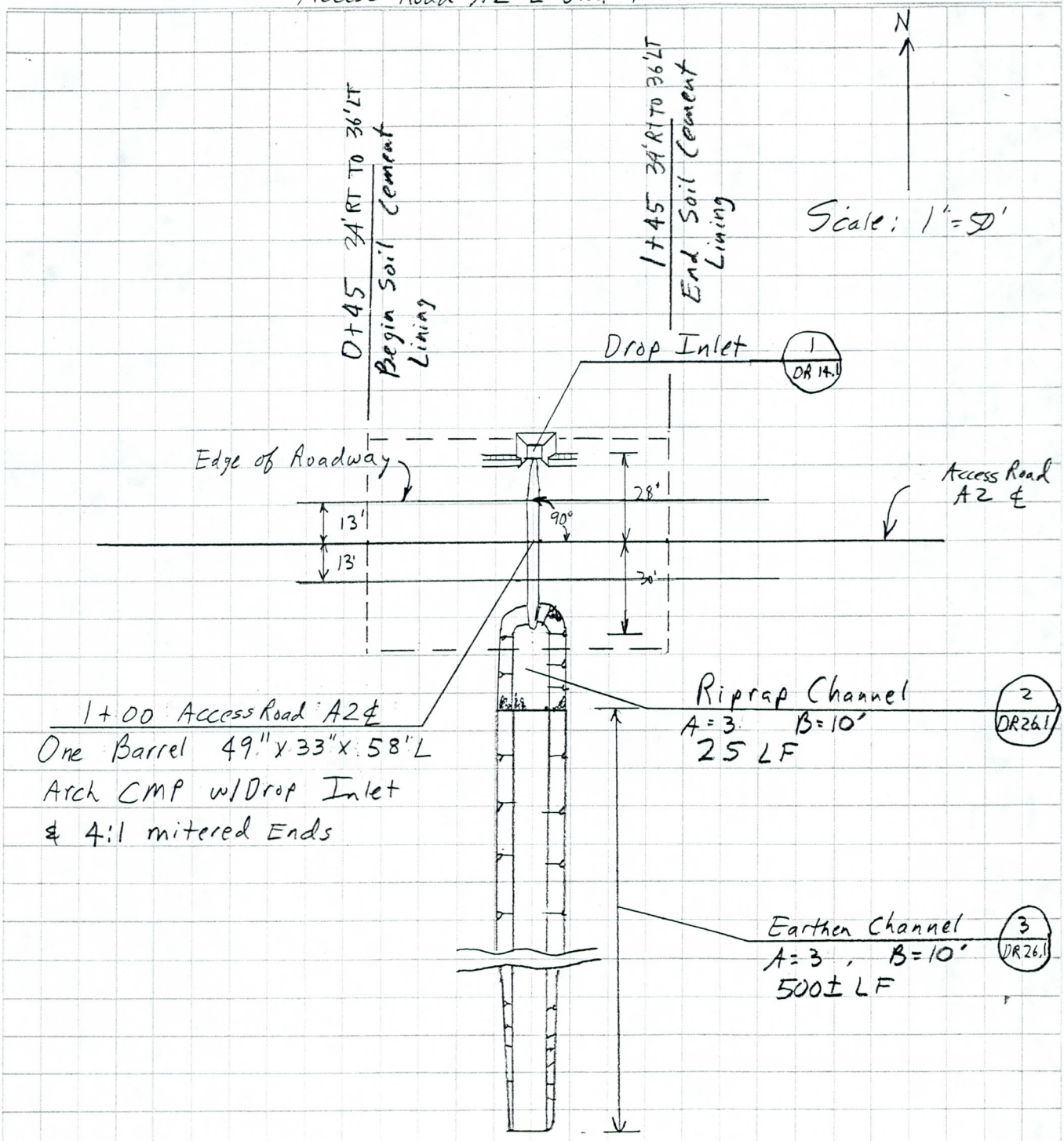
JOB 40477 Toyota

COMPUTATIONS FOR Culvert 45 Plan View
Access Road A2 & Sta. 1+00

SHEET NO. _____ OF _____

DATE 9-8-91

BY DFP CHKD RJT



45 Pipe Culvert Plan
Sta 1+00 Access Road A2
See Profile Dwg. DR-14.1

SVERDRUP

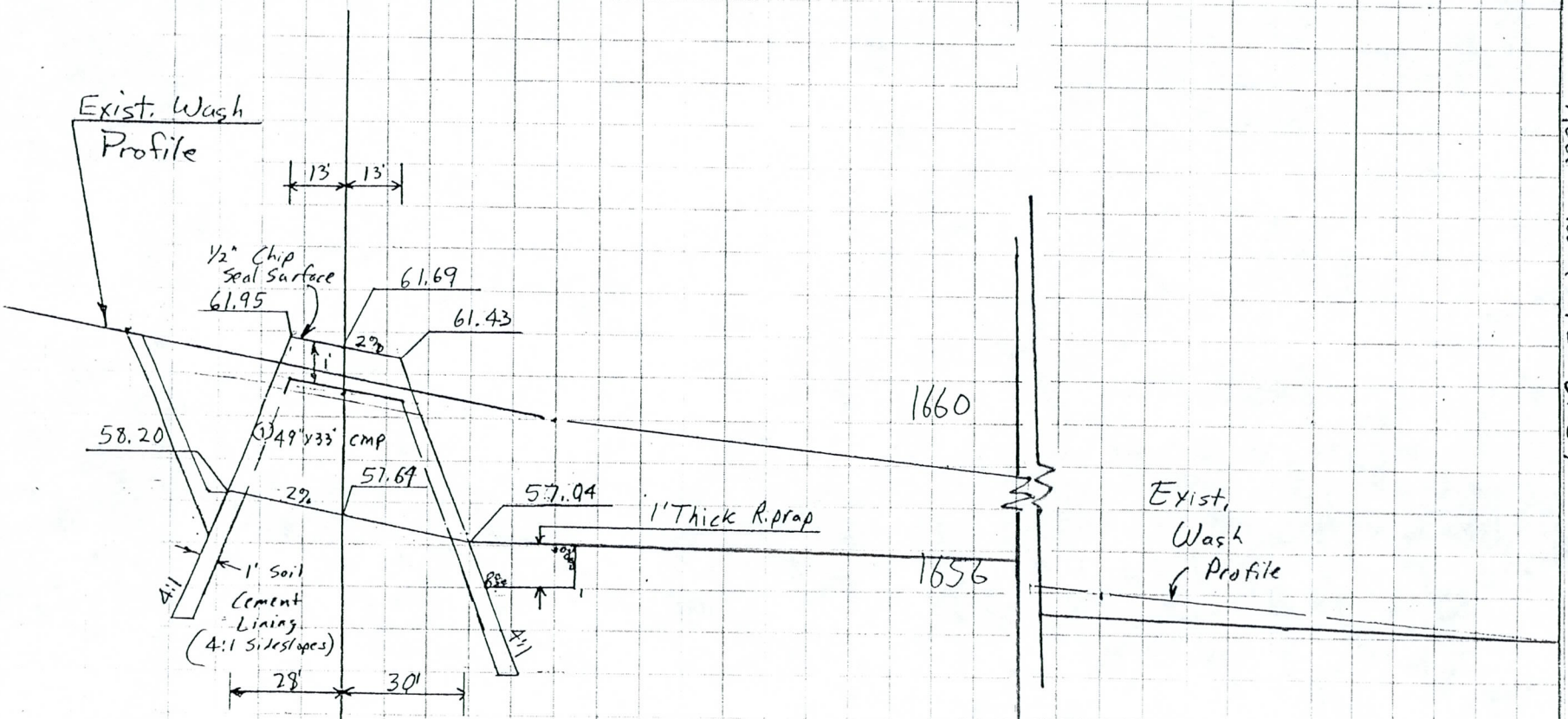
JOB 40477 Toyota SHEET NO. OF

COMPUTATIONS FOR Culvert 45 Profile DATE 8-29-91

Access Road A2 Sta 1+00 BY DFP CHKD RJT

Culvert No. 45 45

0° Skew



Access Road A2
Sta. 1+00

Scale
1" = 40' Horiz
1" = 4' Vert.

45 Pipe Culvert Profile
Sta 1+00 Access Road A2
See Plan Dwg. DR-6.1

SECTION NUMBER A2 100 9/9/91

Channel Slope: 0.0111 ft./ft.

CROSS SECTION DATA:

OFFSET	0	20	60	80	100	120	140	180
ELEV.	62.83	62.43	61.84	61.71	61.69	61.77	61.95	62.65
N	N/A	0.025	0.025	0.025	0.025	0.025	0.025	0.025

STAGE-DISCHARGE DATA:

STAGE: 61.68											
WET PER.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
AREA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYD.RAD.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Q	0	0	0	0	0	0	0	0	0	0	0

STAGE: 61.76											
WET PER.	0.0	0.0	7.7	27.7	45.2	0.0	0.0	0.0	0.0	0.0	0.0
AREA	0.0	0.0	0.2	1.4	2.0	0.0	0.0	0.0	0.0	0.0	0.0
HYD.RAD.	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Q	0	0	0	0	2	0	0	0	0	0	0

STAGE: 61.84											
WET PER.	0.0	0.0	20.0	40.0	60.0	67.8	0.0	0.0	0.0	0.0	0.0
AREA	0.0	0.0	1.3	4.1	6.3	6.6	0.0	0.0	0.0	0.0	0.0
HYD.RAD.	0.0	0.0	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0
Q	0	0	0	0	0	9	0	0	0	0	0

STAGE: 61.92											
WET PER.	0.0	5.4	25.4	45.4	65.4	82.1	0.0	0.0	0.0	0.0	0.0
AREA	0.0	0.2	3.1	7.5	11.3	12.6	0.0	0.0	0.0	0.0	0.0
HYD.RAD.	0.0	0.0	0.1	0.2	0.2	0.2	0.0	0.0	0.0	0.0	0.0
Q	0	0	0	0	0	23	0	0	0	0	0

STAGE: 62											
WET PER.	0.0	10.9	30.9	50.9	70.9	90.9	93.7	0.0	0.0	0.0	0.0
AREA	0.0	0.9	5.4	11.4	16.8	19.6	19.6	0.0	0.0	0.0	0.0
HYD.RAD.	0.0	0.1	0.2	0.2	0.2	0.2	0.2	0.0	0.0	0.0	0.0
Q	0	0	0	0	0	0	43	0	0	0	0

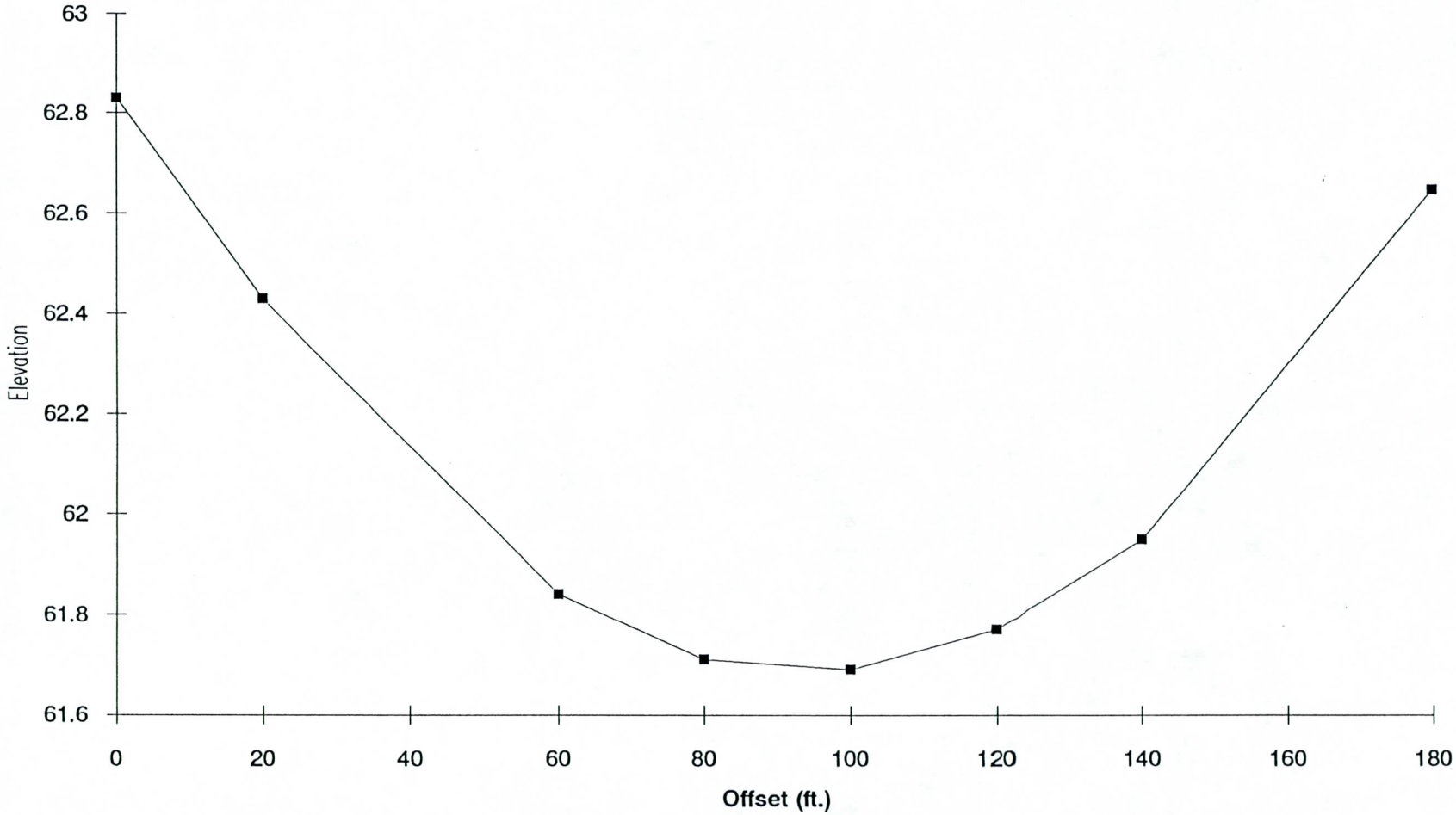
STAGE: 62.08											
WET PER.	0.0	16.3	36.3	56.3	76.3	96.3	103.7	0.0	0.0	0.0	0.0
AREA	0.0	2.0	8.1	15.7	22.7	27.1	27.5	0.0	0.0	0.0	0.0
HYD.RAD.	0.0	0.1	0.2	0.3	0.3	0.3	0.3	0.0	0.0	0.0	0.0
Q	0	0	0	0	0	0	71	0	0	0	0

SECTION NUMBER A2 100 9/9/91

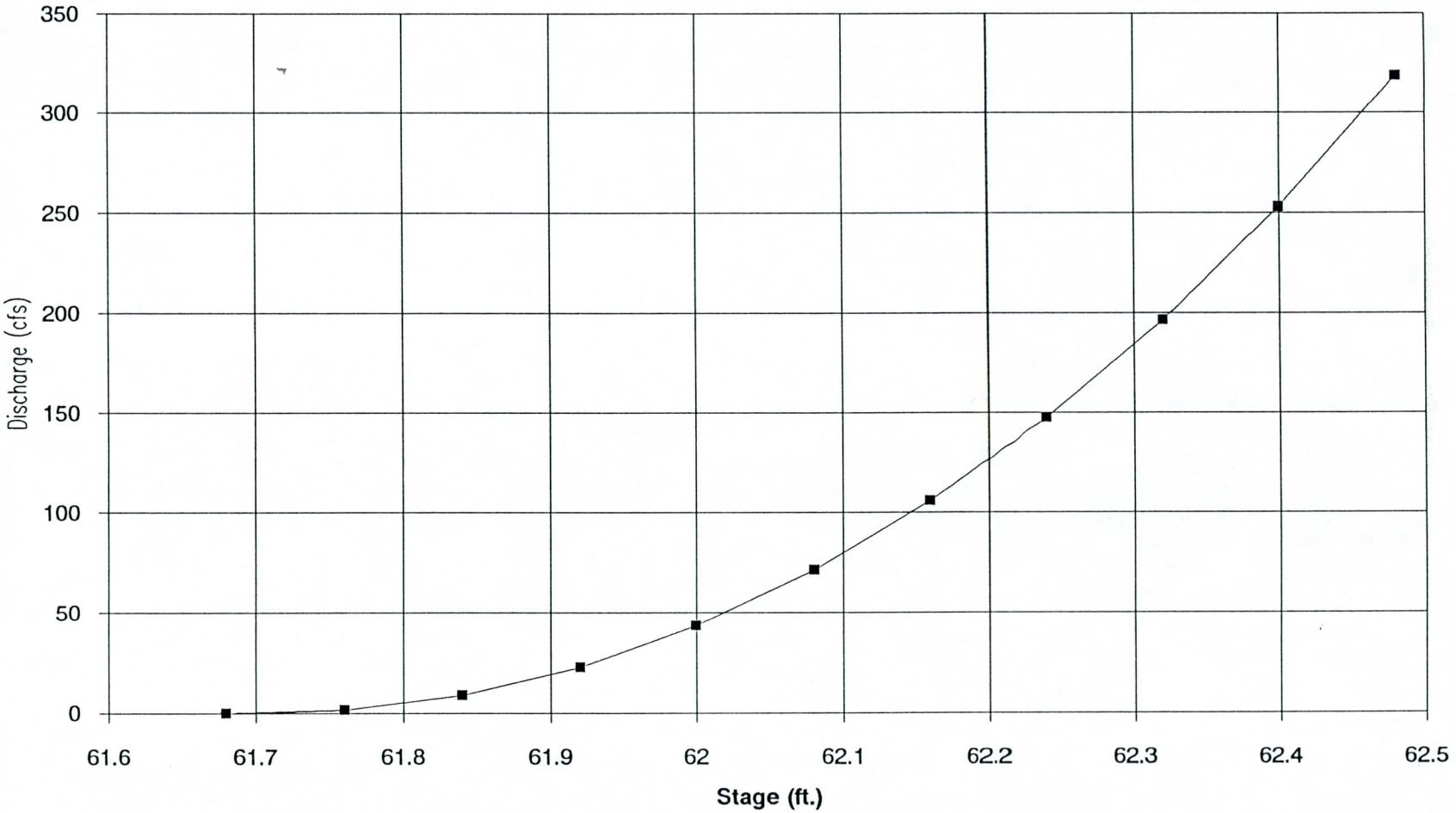
STAGE:	62.16										
WET PER.		0.0	21.7	41.7	61.7	81.7	101.7	113.7	0.0	0.0	0.0	0.0
AREA		0.0	3.5	11.2	20.4	29.0	35.0	36.2	0.0	0.0	0.0	0.0
HYD.RAD.		0.0	0.2	0.3	0.3	0.4	0.3	0.3	0.0	0.0	0.0	0.0
Q		0	0	0	0	0	0	106	0	0	0	0
STAGE:	62.24											
WET PER.		0.0	27.1	47.1	67.1	87.1	107.1	123.7	0.0	0.0	0.0	0.0
AREA		0.0	5.4	14.7	25.5	35.7	43.3	45.7	0.0	0.0	0.0	0.0
HYD.RAD.		0.0	0.2	0.3	0.4	0.4	0.4	0.4	0.0	0.0	0.0	0.0
Q		0	0	0	0	0	0	148	0	0	0	0
STAGE:	62.32											
WET PER.		0.0	32.6	52.6	72.6	92.6	112.6	133.7	0.0	0.0	0.0	0.0
AREA		0.0	7.8	18.7	31.1	42.9	52.1	56.0	0.0	0.0	0.0	0.0
HYD.RAD.		0.0	0.2	0.4	0.4	0.5	0.5	0.4	0.0	0.0	0.0	0.0
Q		0	0	0	0	0	0	196	0	0	0	0
STAGE:	62.4											
WET PER.		0.0	38.0	58.0	78.0	98.0	118.0	143.7	0.0	0.0	0.0	0.0
AREA		0.0	10.6	23.1	37.1	50.5	61.3	67.1	0.0	0.0	0.0	0.0
HYD.RAD.		0.0	0.3	0.4	0.5	0.5	0.5	0.5	0.0	0.0	0.0	0.0
Q		0	0	0	0	0	0	253	0	0	0	0
STAGE:	62.48											
WET PER.		2.5	42.5	62.5	82.5	102.5	122.5	152.8	0.0	0.0	0.0	0.0
AREA		0.1	13.9	28.0	43.6	58.6	71.0	79.0	0.0	0.0	0.0	0.0
HYD.RAD.		0.0	0.3	0.4	0.5	0.6	0.6	0.5	0.0	0.0	0.0	0.0
Q		0	0	0	0	0	0	319	0	0	0	0

W.S. Elev.	61.68	61.76	61.84	61.92	62	62.08	62.16	62.24	62.32	62.4	62.48
Q	0	2	9	23	43	71	106	148	196	253	319
A	0.0	2.0	6.6	12.6	19.6	27.5	36.2	45.7	56.0	67.1	79.0
V	0.0	0.8	1.3	1.8	2.2	2.6	2.9	3.2	3.5	3.8	4.0

Cross Section - A2 100



Stage Discharge - A2 100



SVERDRUP

JOB 40[illegible]77 Toyota SHEET NO [illegible] OF [illegible]

DATE 4/5/91

COMPUTATIONS FOR Culvert No 46 [46] BY BDO CHKD RJT

CULVERT COMPUTATION SHEET

PROJECT: [illegible]

STATION: 5+10, Access Rd A-2

DESIGNER: [illegible]

DATE: [illegible]

HYDROLOGIC AND CHANNEL INFORMATION

DRAINAGE AREA [illegible]

Q_1 = 240 cfs* (0.5' water over Road) TW_1 = 2.60'

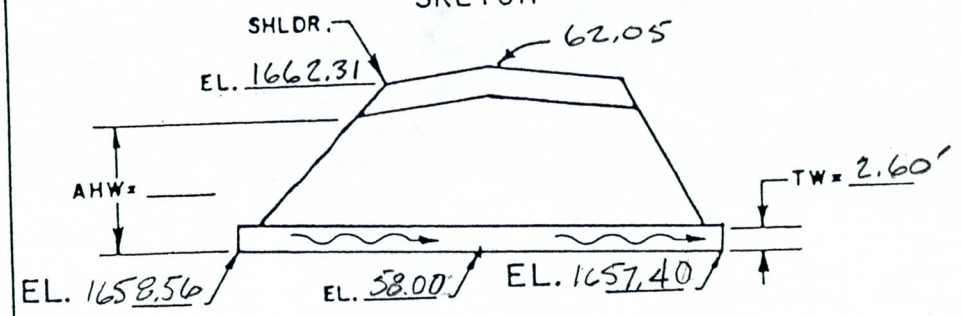
Q_2 = 108 cfs (no water over Road) TW_2 = 1.71'

* 120 cfs over roadway w/ 120 cfs through culverts

Low Flow Crossing

(Q_1 = DESIGN DISCHARGE, SAY Q_{25}; Q_2 = CHECK DISCHARGE, SAY Q_{50})

SKETCH



S_o = 0.02', L = 58' L/100 S_o = [illegible]

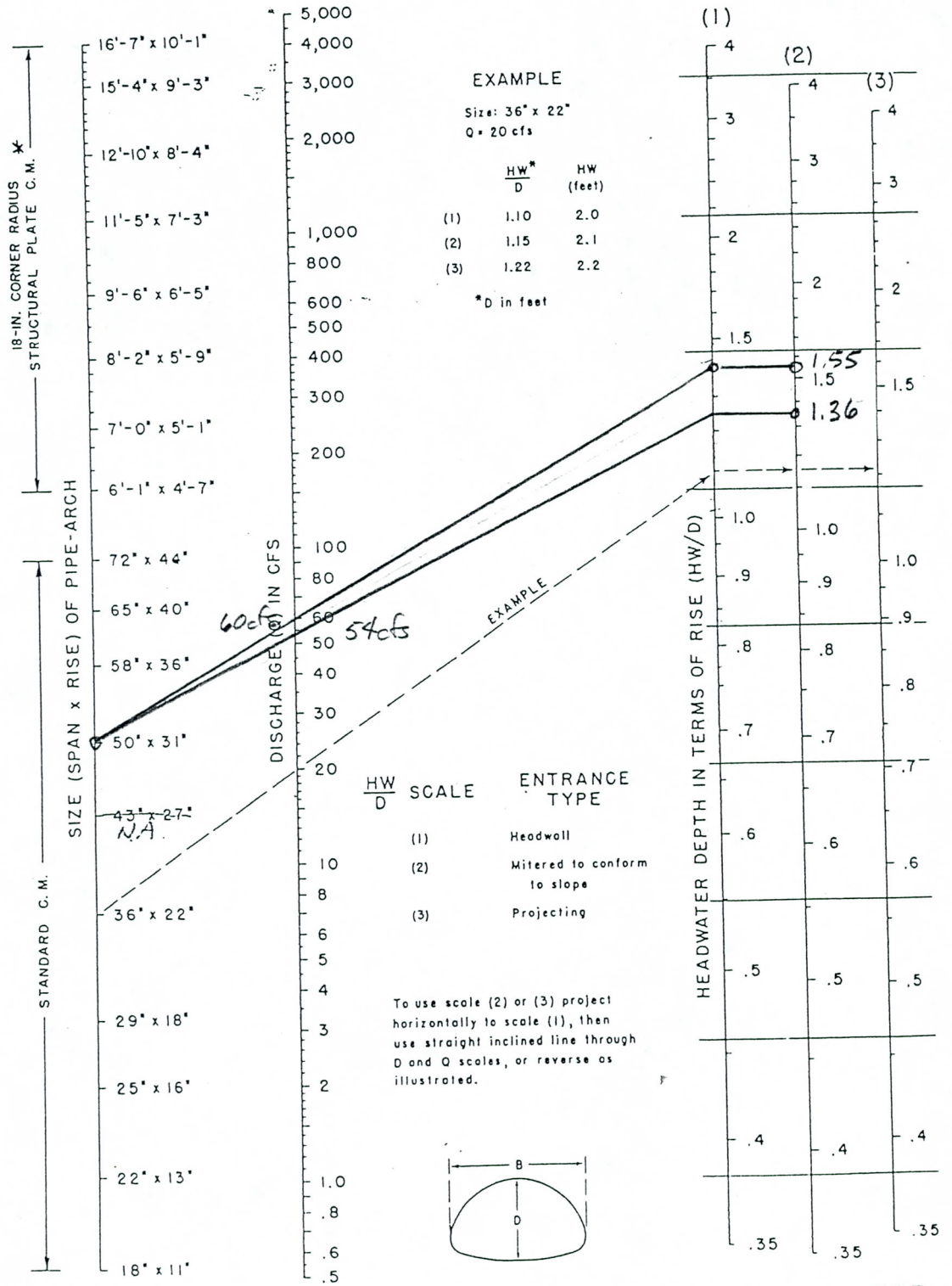
MEAN STREAM VELOCITY = 4.7 fps

CULVERT DESCRIPTION SIZE	CULVERT DESCRIPTION ENTR. TYPE	Q	CAP. CHART HW	HEADWATER COMPUTATION: INLET CONT. HW/D	INLET CONT. HW	OUTLET CONTROL K_e	OUTLET CONTROL H	OUTLET CONTROL d_c	OUTLET CONTROL $\frac{d_c+D}{2}$	OUTLET CONTROL TW	OUTLET CONTROL h_o	OUTLET CONTROL LS_o	OUTLET CONTROL HW	CONTROL HW	OUTLET VELOCITY	COST	DHW ELEV.	COMMENTS
Cmp Arch (2) 49"x33"	Drop Inlet w/ Mitered Ends	60		1.55	4.25	0.7	2.35	1.87	2.31	2.60	2.60	1.16	3.79	4.25	8.5		1662.81	Inlet Control
"	"	54		1.36	3.75	0.7	1.90	1.75	2.25	1.71	2.25	1.16	2.99	3.75	8.2		1662.31	Inlet Control

SUMMARY & RECOMMENDATIONS Use dumped riprap downstream of culvert for erosion protection. Use soil cement embankment protection from Sta 4+65 to 5+65 for dip crossing.

Culvert No. 46

CHART 6



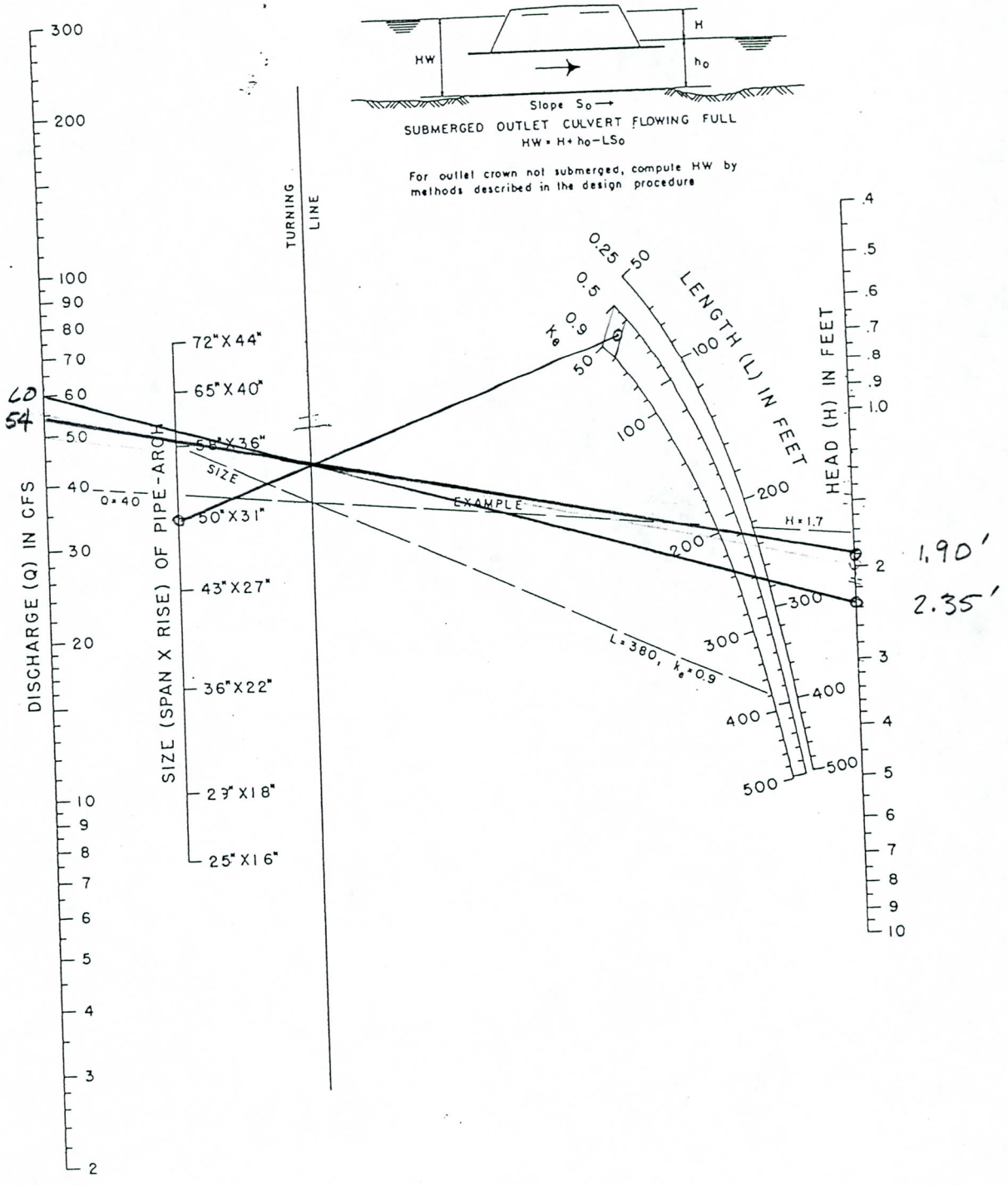
* ADDITIONAL SIZES NOT DIMENSIONED ARE LISTED IN FABRICATOR'S CATALOG

BUREAU OF PUBLIC ROADS JAN 1963

HEADWATER DEPTH FOR C. M. PIPE-ARCH CULVERTS WITH INLET CONTROL

Culvert No. 46

CHART 12

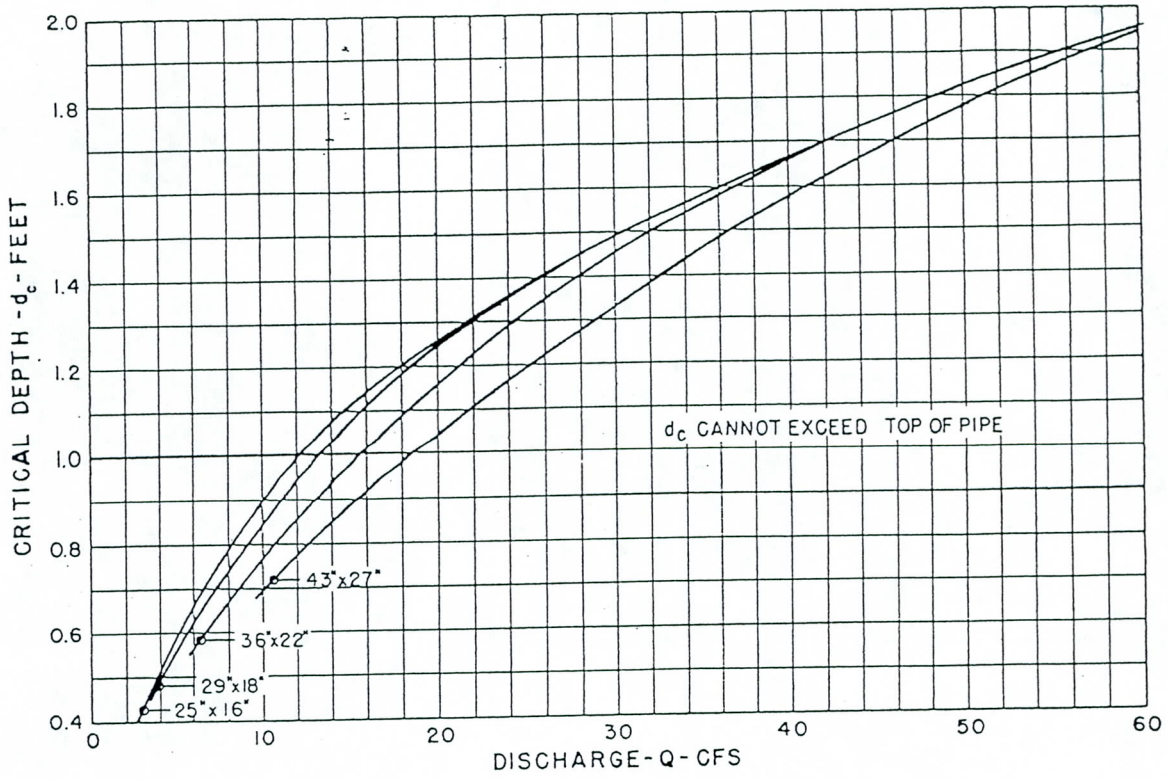


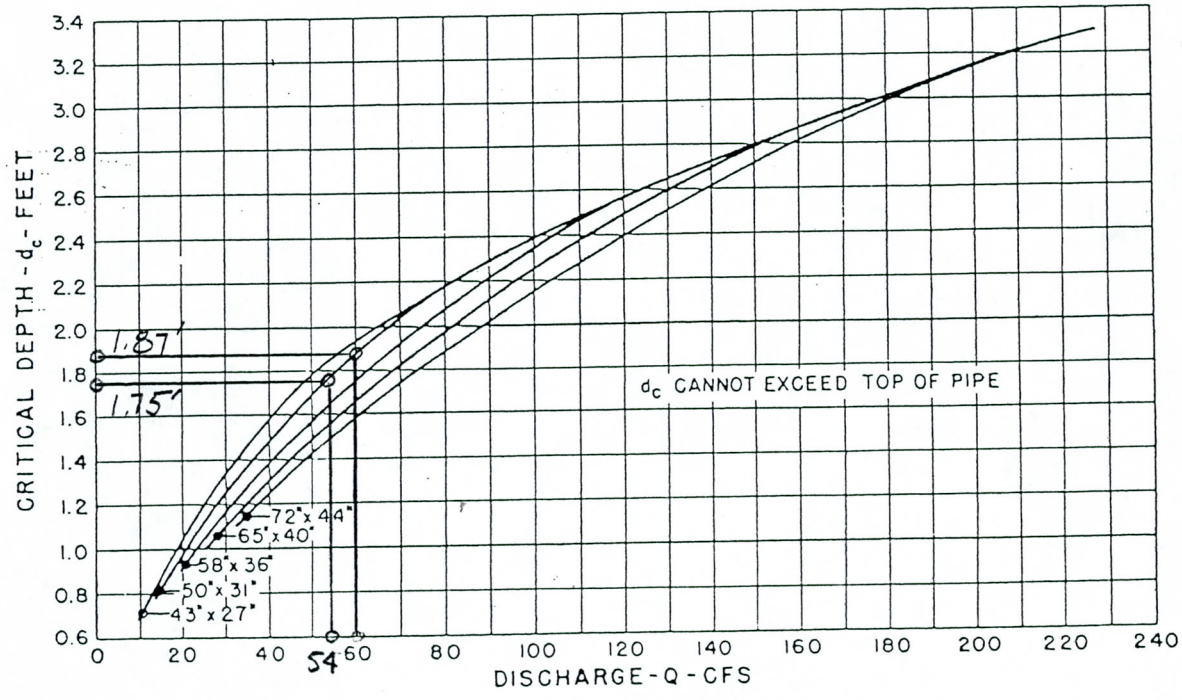
HEAD FOR
STANDARD C. M. PIPE-ARCH CULVERTS
FLOWING FULL
n = 0.024

BUREAU OF PUBLIC ROADS JAN. 1963

Culvert No. 46

CHART 19





BUREAU OF PUBLIC ROADS

JAN. 1964

CRITICAL DEPTH
STANDARD C.M. PIPE-ARCH

SVERDRUP

JOB 40477 Toyota SHEET NO. ____ OF ____

COMPUTATIONS FOR Culvert No 46 DATE 9/9/91

BY BDO CHKD RJT

From CMP Arch Table 4-15

For a Full Pipe (49" x 33")

Hydraulic Radius = 0.81 ft

Area = 8.90 ft²

Using Mannings Eqn. w/ S = 0.02 ft/ft, n = 0.024

$$Q = \frac{1.49}{.024}(8.9)(0.81)^{0.666}(0.02)^{0.5} = 67.9 \text{ cfs}$$

(From Figure 4-38)

$$\frac{Q_P}{Q_{Full}} = \frac{54}{67.9} = 0.80 \Rightarrow \frac{A}{A_{Full}} = 0.74$$

$$V = \frac{Q}{A} = \frac{54}{0.74(8.9)} = 8.2 \text{ fps}$$

For

$$\frac{Q_P}{Q_{Full}} = \frac{60}{67.9} = 0.88 \Rightarrow \frac{A}{A_{Full}} = 0.79$$

$$V = \frac{Q}{A} = \frac{60}{0.79(8.9)} = 8.5 \text{ fps}$$

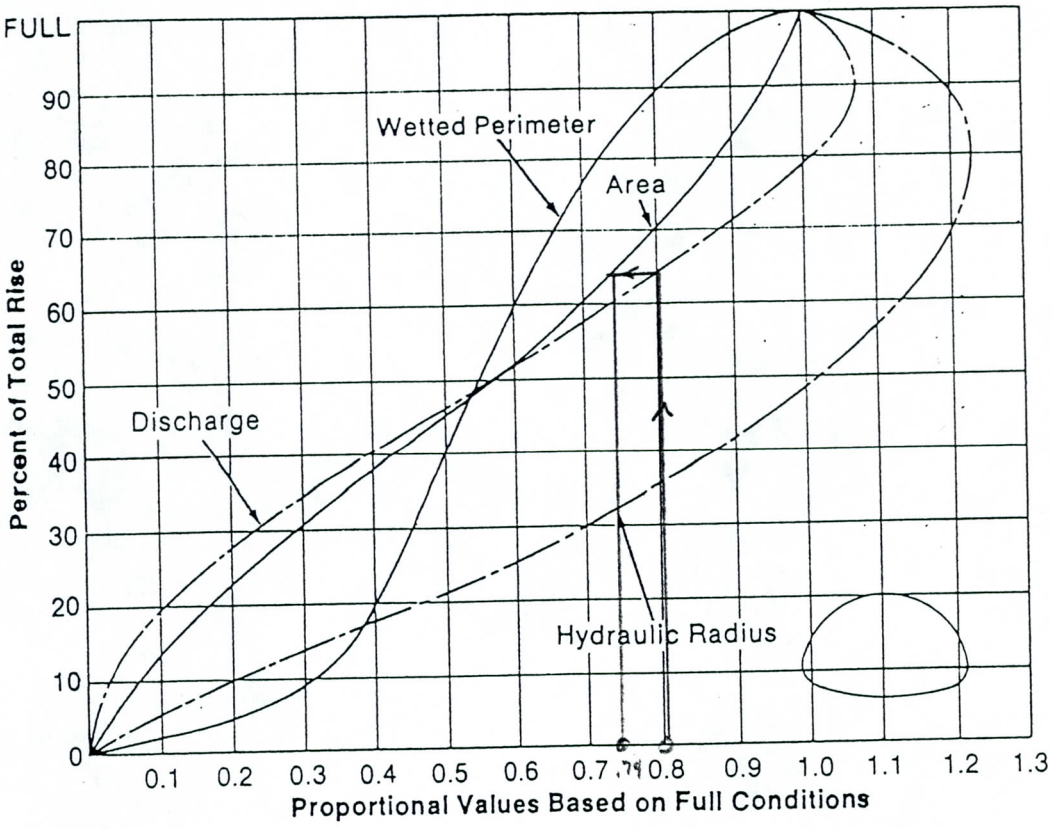


Figure 4-38 Hydraulic properties of corrugated steel and structural plate pipe-arches.

Table 4-15 Full-Flow Data for Corrugated Steel Pipe Arches

Corrugations 2⅔ × ½ in.					Corrugations 3 × 1 in. and 5 × 1 in.			
Dimensions, in.			Waterway Area, ft²	Hydraulic Radius A/πD, ft	Diameter, in.	Equiv. Size, in.	Waterway Area, ft²	Hydraulic Radius A/πD, ft
Pipe Diameter	Pipe-Arch Span	Pipe-Arch Rise						
15	17	13	1.1	0.280	54	60 × 46	15.6	1.104
18	21	15	1.6	0.340	60	66 × 51	19.3	1.230
21	24	18	2.2	0.400	66	73 × 55	23.2	1.343
24	28	20	2.9	0.462	72	81 × 59	27.4	1.454
30	35	24	4.5	0.573	78	87 × 63	32.1	1.573
36	42	29	6.5	0.69	84	95 × 67	37.0	1.683
*42	49	33	8.9	0.81	90	103 × 71	42.4	1.80
*48	57	38	11.6	0.924	96	112 × 75	48.0	1.911
*54	64	43	14.7	1.04	102	117 × 79	54.2	2.031
*60	71	47	18.1	1.153	108	128 × 83	60.5	2.141
*66	77	52	21.9	1.268	114	137 × 87	67.4	2.259
*72	83	57	26.0	1.38	120	142 × 91	74.5	2.373

SVERDRUP

JOB 40477 Toyota SHEET NO. ____ OF ____

DATE 9/5/91

COMPUTATIONS FOR Channel Section Downstream of Culvert 46 BY BDO CHKD RJT

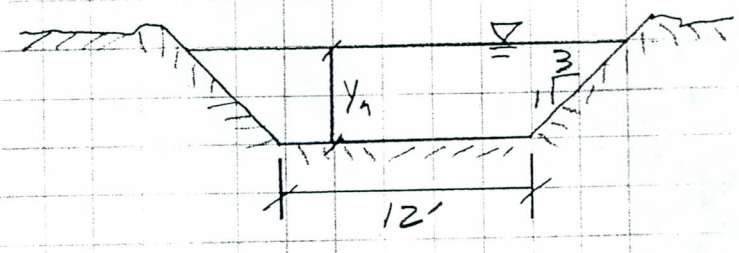
Check depth of flow using Mannings Eqn.

$Q = 240$ cfs

$n = 0.03$

$S_o = 0.0040$ ft/ft

$Y_n \approx 2.60'$



$A = 51.54$ ft^2

$WP = 2(8.22') + 12' = 28.44$ ft

$R_h = A/WP = 51.54/28.44 = 1.8122$ ft

$$V = \frac{1.49}{.03}(1.8122)^{.666}(.0040)^{.5} = 4.67 \text{ fps}$$

check

$Q = VA = 4.67(51.54) = 241$ cfs (OK)

For $Q = 108$ cfs

$Y_n = 1.71'$, $V = 3.70$ fps

SVERDRUP

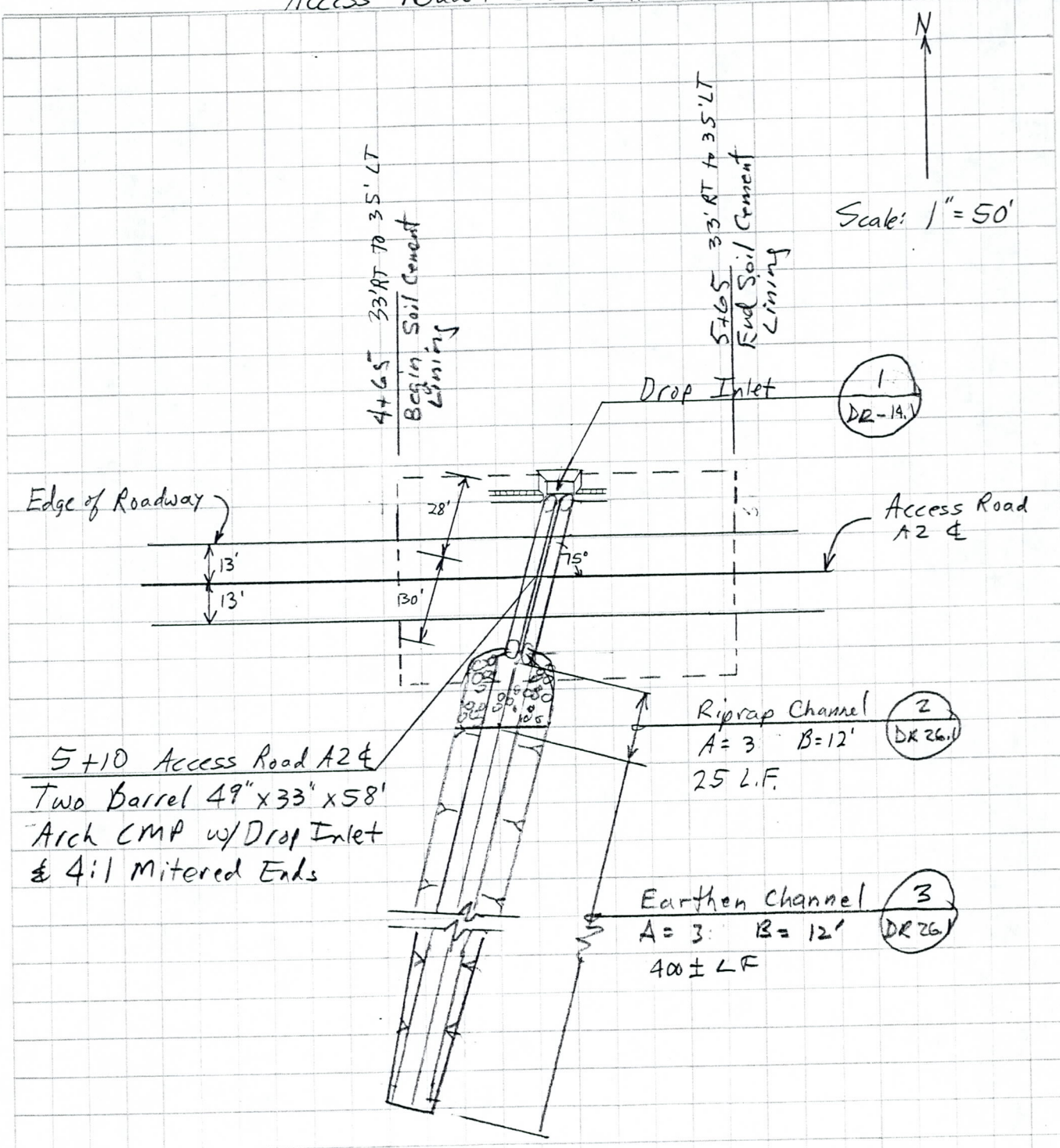
JOB 40477 Toyota

COMPUTATIONS FOR Culvert 46 Plan View
Access Road A2 ℄ Sta. 5+10

SHEET NO. _____ OF _____

DATE 9-8-91

BY DFP CHKD RJT



46 Pipe Culvert Plan
Sta. 5+10 Access Road A2
See Profile Dwg. DR 14.1

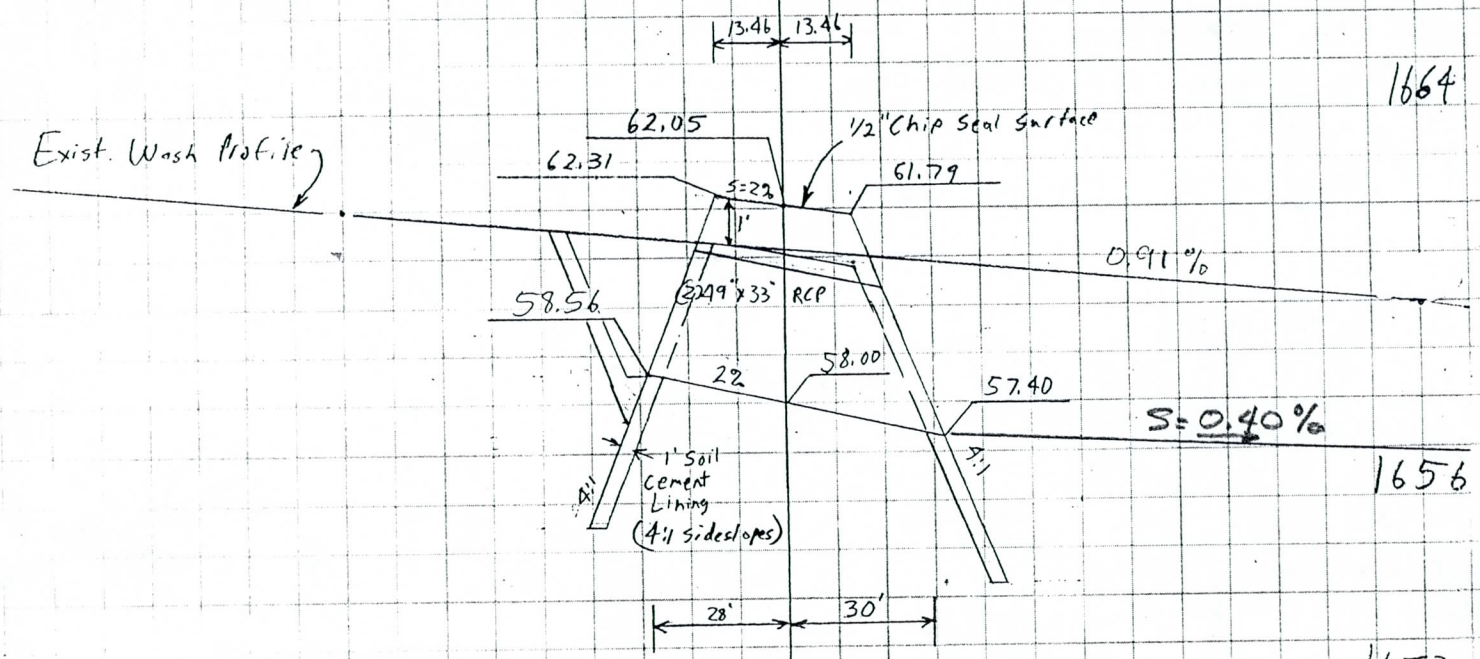
SVERDRUP

JOB 40477 Toyota SHEET NO. OF

COMPUTATIONS FOR Culvert 46 Profile DATE 8-28-91

Access Road A2 Sta 5+10 BY DFP CHKD RJT

Skew = 15°



1664

1656

1652

1648

Access Road A2
Sta. 5+10

46 Pipe Culvert Profile
Sta 5+10 Access Road A2
See Plan Dwg. DR-6.1

SECTION NUMBER A1 500 8/30/91

Channel Slope: 0.0091 ft./ft.

CROSS SECTION DATA:

OFFSET	400	437.5	450	475	500	525	550	562.5	800
ELEV.	63.48	62.77	62.55	62.23	62.06	62.04	62.18	62.31	65.06
N	N/A	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025

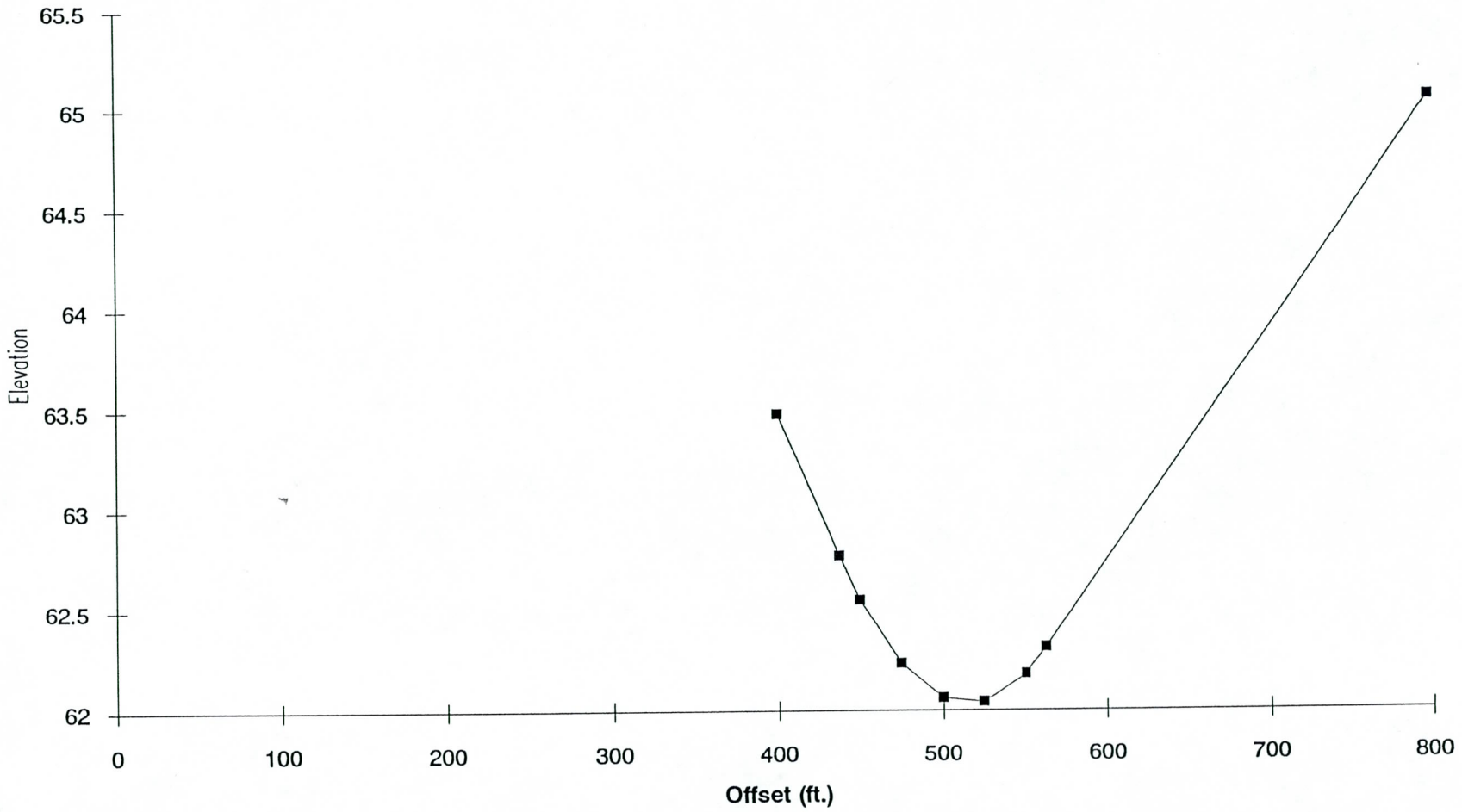
STAGE-DISCHARGE DATA:

STAGE:	62										
WET PER.		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
AREA		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYD.RAD.		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Q		0	0	0	0	0	0	0	0	0	0	0
STAGE:	62.1											
WET PER.		0.0	0.0	0.0	5.9	30.9	41.6	0.0	0.0	0.0	0.0	0.0
AREA		0.0	0.0	0.0	0.1	1.4	1.7	0.0	0.0	0.0	0.0	0.0
HYD.RAD.		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Q		0	0	0	0	0	1	0	0	0	0	0
STAGE:	62.2											
WET PER.		0.0	0.0	0.0	20.6	45.6	70.6	72.5	0.0	0.0	0.0	0.0
AREA		0.0	0.0	0.0	1.4	5.2	7.4	7.5	0.0	0.0	0.0	0.0
HYD.RAD.		0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0
Q		0	0	0	0	0	0	9	0	0	0	0
STAGE:	62.3											
WET PER.		0.0	0.0	5.5	30.5	55.5	80.5	92.0	0.0	0.0	0.0	0.0
AREA		0.0	0.0	0.2	4.1	10.3	15.1	15.8	0.0	0.0	0.0	0.0
HYD.RAD.		0.0	0.0	0.0	0.1	0.2	0.2	0.2	0.0	0.0	0.0	0.0
Q		0	0	0	0	0	0	28	0	0	0	0
STAGE:	62.4											
WET PER.		0.0	0.0	13.3	38.3	63.3	88.3	100.8	108.6	0.0	0.0	0.0
AREA		0.0	0.0	1.1	7.5	16.3	23.5	25.4	25.8	0.0	0.0	0.0
HYD.RAD.		0.0	0.0	0.1	0.2	0.3	0.3	0.3	0.2	0.0	0.0	0.0
Q		0	0	0	0	0	0	0	56	0	0	0
STAGE:	62.5											
WET PER.		0.0	0.0	21.1	46.1	71.1	96.1	108.6	125.0	0.0	0.0	0.0
AREA		0.0	0.0	2.8	11.7	23.0	32.7	35.9	37.5	0.0	0.0	0.0
HYD.RAD.		0.0	0.0	0.1	0.3	0.3	0.3	0.3	0.3	0.0	0.0	0.0

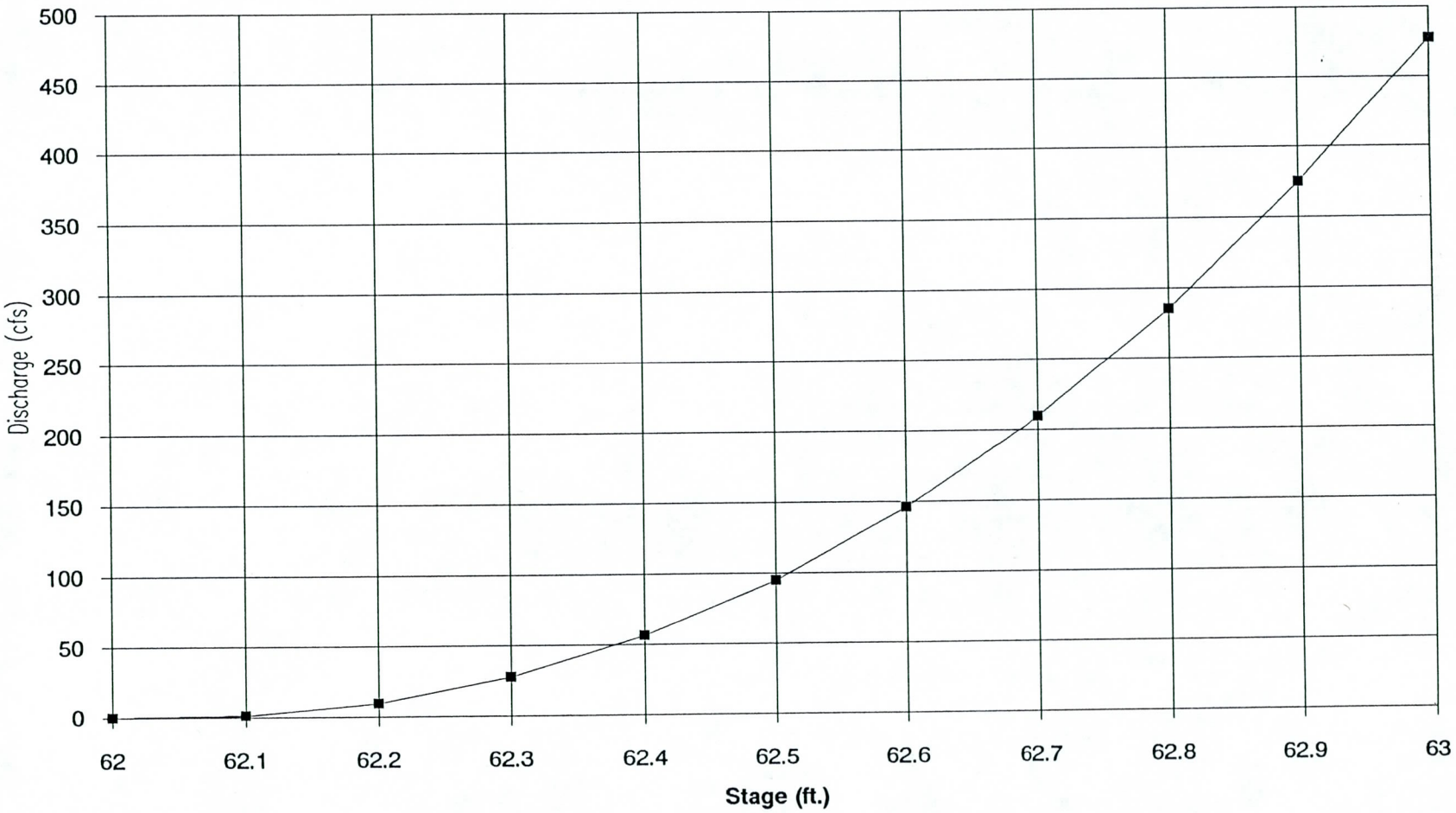
STAGE:	62.6										
WET PER.		0.0	2.8	27.8	52.8	77.8	102.8	115.3	140.4	0.0	0.0	0.0
AREA		0.0	0.1	5.3	16.7	30.4	42.7	47.1	50.8	0.0	0.0	0.0
HYD.RAD.		0.0	0.0	0.2	0.3	0.4	0.4	0.4	0.4	0.0	0.0	0.0
Q		0	0	0	0	0	0	0	146	0	0	0
STAGE:	62.7											
WET PER.		0.0	8.5	33.5	58.5	83.5	108.5	121.0	154.7	0.0	0.0	0.0
AREA		0.0	0.6	8.4	22.3	38.5	53.3	59.0	65.5	0.0	0.0	0.0
HYD.RAD.		0.0	0.1	0.3	0.4	0.5	0.5	0.5	0.4	0.0	0.0	0.0
Q		0	0	0	0	0	0	0	210	0	0	0
STAGE:	62.8											
WET PER.		1.6	14.1	39.1	64.1	89.1	114.1	126.6	168.9	0.0	0.0	0.0
AREA		0.0	1.8	12.0	28.4	47.1	64.4	71.3	81.7	0.0	0.0	0.0
HYD.RAD.		0.0	0.1	0.3	0.4	0.5	0.6	0.6	0.5	0.0	0.0	0.0
Q		0	0	0	0	0	0	0	285	0	0	0
STAGE:	62.9											
WET PER.		6.9	19.4	44.4	69.4	94.4	119.4	131.9	182.8	0.0	0.0	0.0
AREA		0.4	3.4	16.2	35.1	56.3	76.1	84.3	99.3	0.0	0.0	0.0
HYD.RAD.		0.1	0.2	0.4	0.5	0.6	0.6	0.6	0.5	0.0	0.0	0.0
Q		0	0	0	0	0	0	0	375	0	0	0
STAGE:	63											
WET PER.		12.2	24.7	49.7	74.7	99.7	124.7	137.2	196.7	0.0	0.0	0.0
AREA		1.4	5.6	20.9	42.3	66.0	88.3	97.7	118.3	0.0	0.0	0.0
HYD.RAD.		0.1	0.2	0.4	0.6	0.7	0.7	0.7	0.6	0.0	0.0	0.0
Q		0	0	0	0	0	0	0	478	0	0	0

W.S. Elev.	62	62.1	62.2	62.3	62.4	62.5	62.6	62.7	62.8	62.9	63
Q	0	1	9	28	56	95	146	210	285	375	478
A	0.0	1.7	7.5	15.8	25.8	37.5	50.8	65.5	81.7	99.3	118.3
V	0.0	0.7	1.2	1.7	2.2	2.5	2.9	3.2	3.5	3.8	4.0

Cross Section - A1 500



Stage Discharge - A1 500



SVERDRUP

JOB 4017 Toyota

COMPUTATIONS FOR Culvert No. 47 [47]

SHEET NO ____ OF ____

DATE 9/5/91

BY BDO CHKD RJT

CULVERT COMPUTATION SHEET

PROJECT: ____

STATION: 12+40, Access Rd A-2

DESIGNER: ____

DATE: ____

HYDROLOGIC AND CHANNEL INFORMATION

DRAINAGE AREA ____

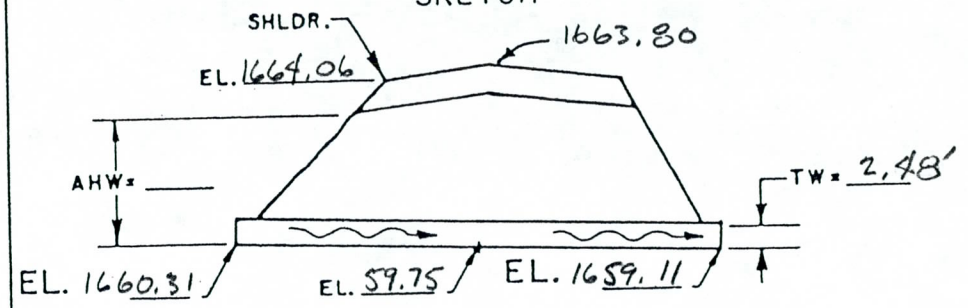
Q_1 = 218 cfs * (0.5' Water over road) TW_1 = 2.48'

Q_2 = 108 cfs (no water over road) TW_2 = 1.71'

* 98 cfs over roadway w/ 120 cfs through culverts.

(Q_1 = DESIGN DISCHARGE, SAY Q_{25}; Q_2 = CHECK DISCHARGE, SAY Q_{50})

SKETCH



S_o = 0.02'/' L = 60' L/100 S_o = ____

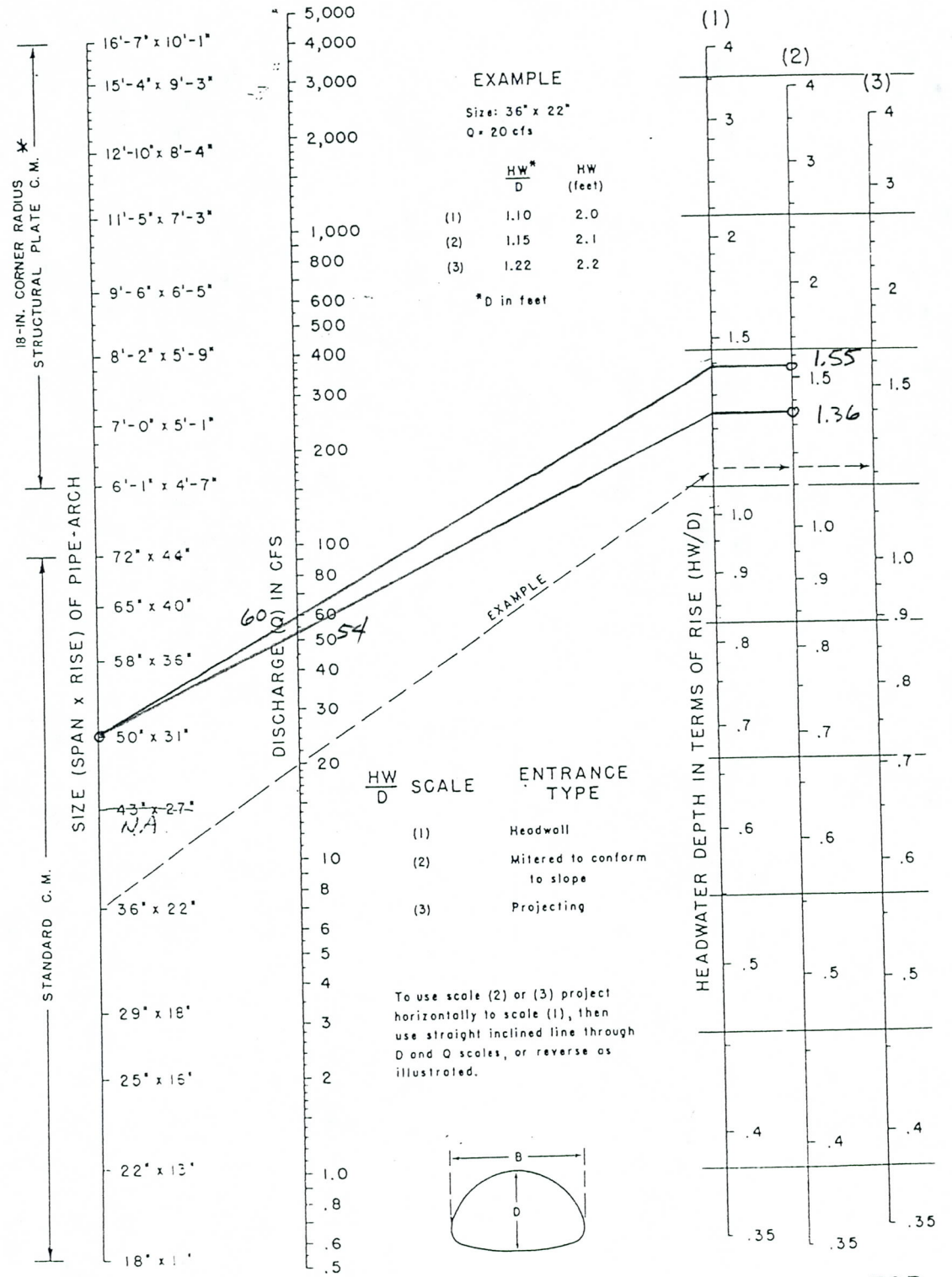
MEAN STREAM VELOCITY = 4.5 fps

CULVERT DESCRIPTION SIZE	CULVERT DESCRIPTION ENTR. TYPE	Q	CAP. CHART HW	HEADWATER COMPUTATION: INLET CONT. HW/D	INLET CONT. HW	OUTLET CONTROL K_e	OUTLET CONTROL H	OUTLET CONTROL d_c	OUTLET CONTROL $\frac{d_c+D}{2}$	OUTLET CONTROL TW	OUTLET CONTROL h_o	OUTLET CONTROL LS_o	OUTLET CONTROL HW	CONTROL HW	OUTLET VELOCITY	COST	DHW ELEV.	COMMENTS
CMPArch (2) 49x33	Drop Inlet w/ Mitered End	60		1.55	4.25	0.7	2.35	1.87	2.31	2.48	2.48	1.20	3.63	4.25	8.5		1664.56	Inlet control
"	"	54		1.36	3.75	0.7	1.90	1.75	2.25	1.71	2.25	1.20	2.95	3.75	8.2		1664.06	Inlet Control

SUMMARY & RECOMMENDATIONS: Use dumped riprap downstream of culvert for erosion protection. Use soil cement embankment protection from Sta 11+95 to 12+95 for dip crossing.

Culvert No. 47

CHART 6



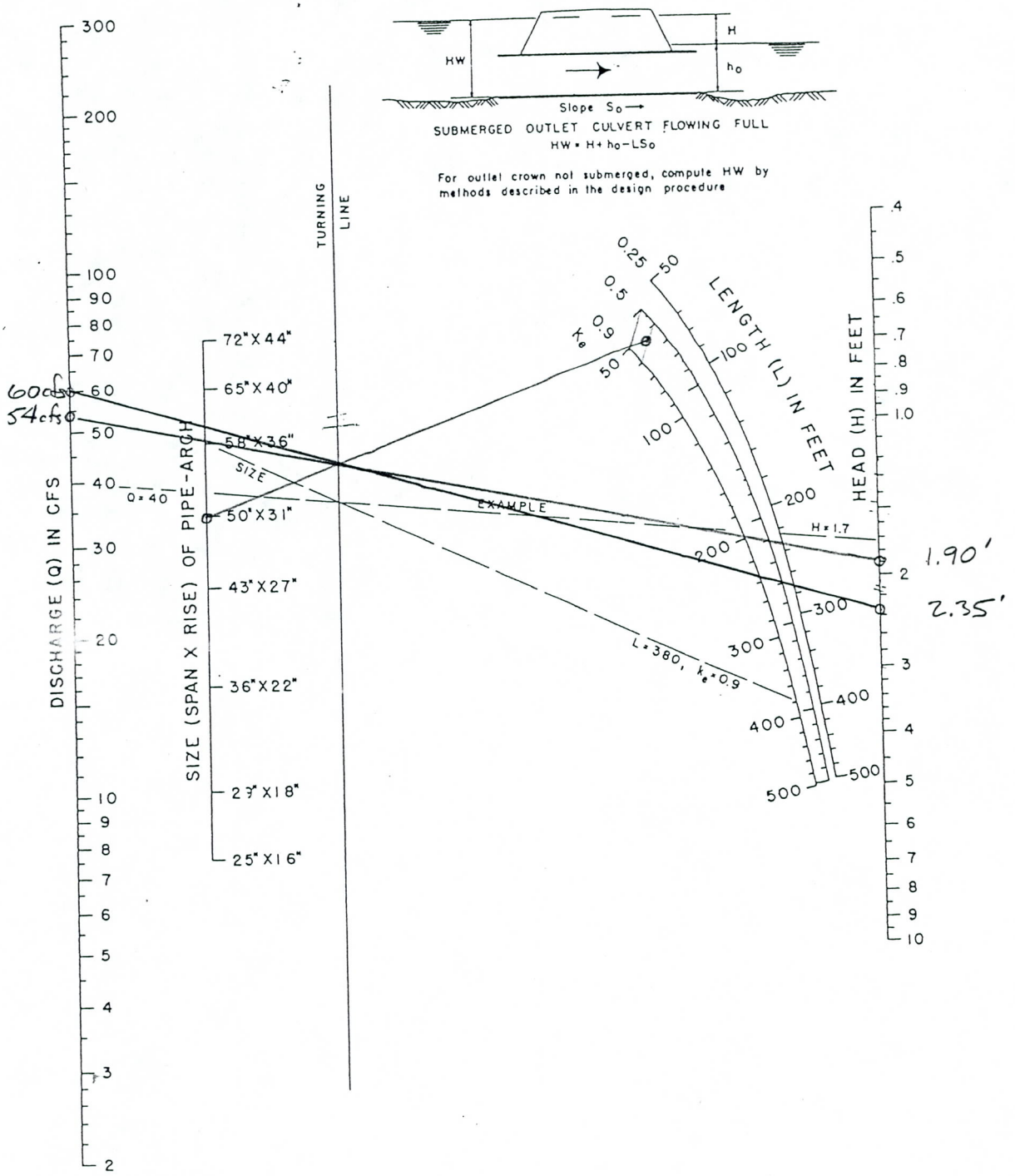
* ADDITIONAL SIZES NOT DIMENSIONED ARE LISTED IN FABRICATOR'S CATALOG

BUREAU OF PUBLIC ROADS JAN 1963

HEADWATER DEPTH FOR C. M. PIPE-ARCH CULVERTS WITH INLET CONTROL

Culvert No. 47

CHART 12

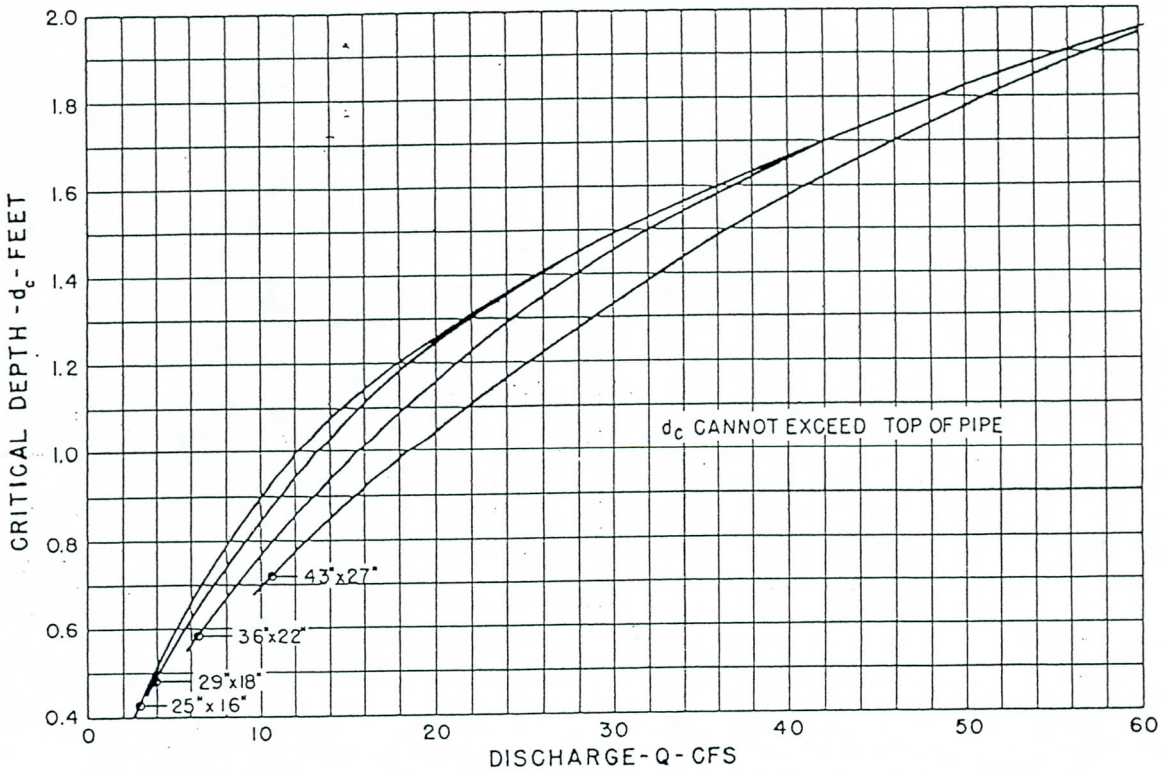


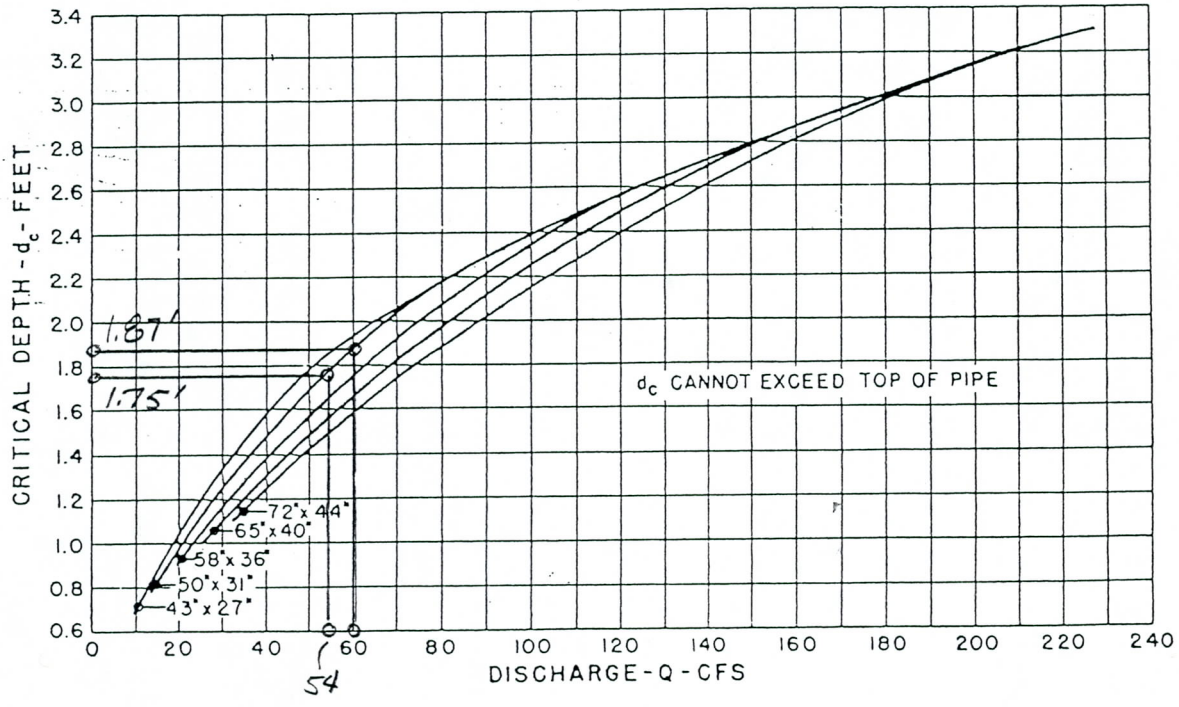
HEAD FOR
STANDARD C. M. PIPE-ARCH CULVERTS
FLOWING FULL
n=0.024

BUREAU OF PUBLIC ROADS JAN. 1963

Culvert No. 47

CHART 19





BUREAU OF PUBLIC ROADS

JAN. 1964

CRITICAL DEPTH
STANDARD C.M. PIPE-ARCH

SVERDRUP

JOB 40477 Toyota

COMPUTATIONS FOR Culvert No 47

SHEET NO. ____ OF ____

DATE 9/9/91

BY BDO CHKD RJT

From CMP Arch Table 4-15

For a Full Pipe (99" x 33")

Hydraulic Radius = 0.81 ft

Area = 8.90 ft²

Using Mannings Eqn. w/ S = 0.02 ft/ft, n = 0.024

$$Q = \frac{1.49}{.024}(8.9)(0.81)^{0.666}(0.02)^{0.5} = 67.9 \text{ cfs}$$

(From Figure 4-38)

$$\frac{Q_P}{Q_{Full}} = \frac{54}{67.9} = 0.80 \Rightarrow \frac{A}{A_{Full}} = 0.74$$

$$V = \frac{Q}{A} = \frac{54}{0.74(8.9)} = 8.2 \text{ fps}$$

For

$$\frac{Q_P}{Q_{Full}} = \frac{60}{67.9} = 0.88 \Rightarrow \frac{A}{A_{Full}} = 0.79$$

$$V = \frac{Q}{A} = \frac{60}{0.79(8.9)} = 8.5 \text{ fps}$$

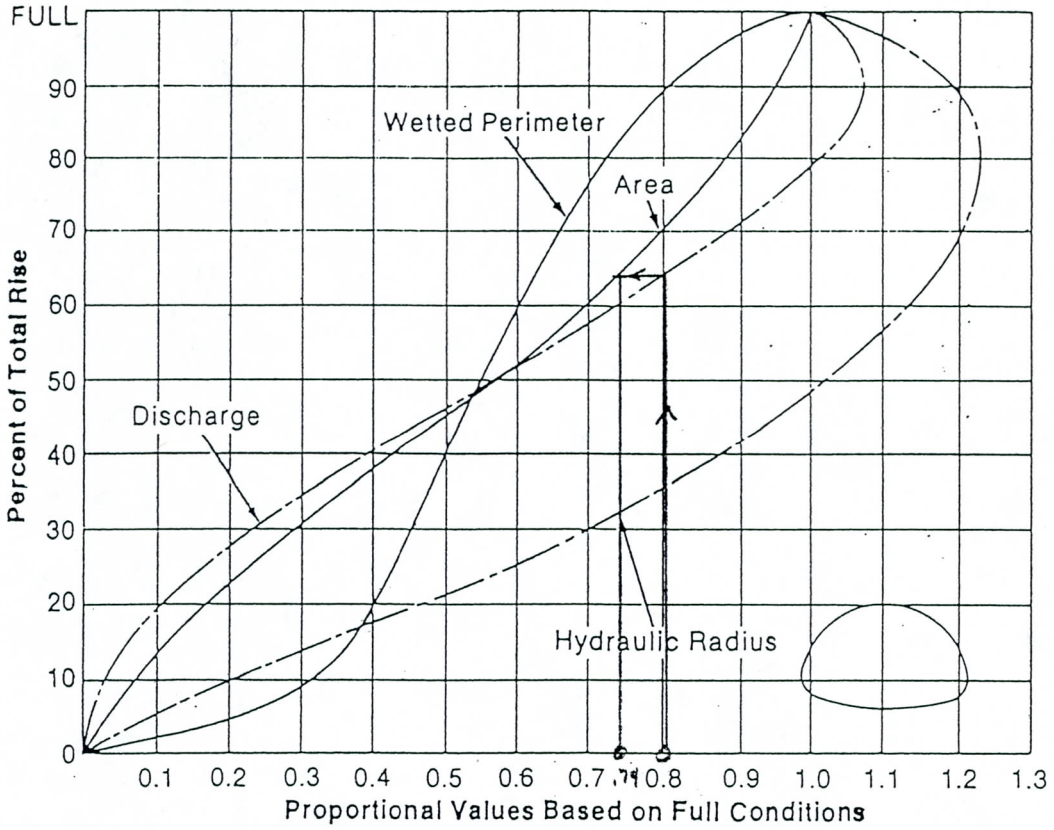


Figure 4-38 Hydraulic properties of corrugated steel and structural plate pipe-arches.

Table 4-15 Full-Flow Data for Corrugated Steel Pipe Arches

Corrugations 2⅔ × ½ in.					Corrugations 3 × 1 in. and 5 × 1 in.			
Dimensions, in.			Waterway Area, ft²	Hydraulic Radius A/πD, ft	Diameter, in.	Equiv. Size, in.	Waterway Area, ft²	Hydraulic Radius A/πD, ft
Pipe Diameter	Pipe-Arch Span	Pipe-Arch Rise						
15	17	13	1.1	0.280	54	60 × 46	15.6	1.104
18	21	15	1.6	0.340	60	66 × 51	19.3	1.230
21	24	18	2.2	0.400	66	73 × 55	23.2	1.343
24	28	20	2.9	0.462	72	81 × 59	27.4	1.454
30	35	24	4.5	0.573	78	87 × 63	32.1	1.573
36	42	29	6.5	0.69	84	95 × 67	37.0	1.683
*42	49	33	8.9	0.81	90	103 × 71	42.4	1.80
*48	57	38	11.6	0.924	96	112 × 75	48.0	1.911
*54	64	43	14.7	1.04	102	117 × 79	54.2	2.031
*60	71	47	18.1	1.153	108	128 × 83	60.5	2.141
*66	77	52	21.9	1.268	114	137 × 87	67.4	2.259
*72	83	57	26.0	1.38	120	142 × 91	74.5	2.373

SVERDRUP

JOB 40477 Toyota SHEET NO. ____ OF ____

DATE 9-6-91

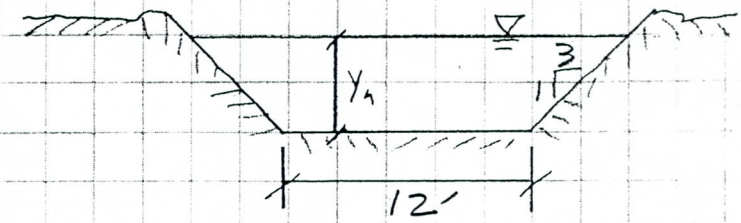
COMPUTATIONS FOR Channel Section Downstream of Culvert 47 BY BDO CHKD RTT

Check depth of flow using Mannings Eqn.

$Q = 218$ cfs

$n = 0.03$

$S_o = 0.0040$ ft/ft



$Y_n \sim 2.48'$

$A = 48.10$ ft^2

$WP = 2(7.84) + 12' = 27.68$ ft

$R_h = A/WP = 48.10/27.68 = 1.7374$ ft

$$V = \frac{1.49}{.03}(1.7374)^{.666}(.0040)^{.5} = 4.54 \text{ fps}$$

check

$Q = VA = 4.54\ (48.10) = 218$ cfs (OK)

For $Q = 108$ cfs

$Y_n = 1.71'$, $V = 3.70$ fps

SVERDRUP

JOB 40477 Toyota

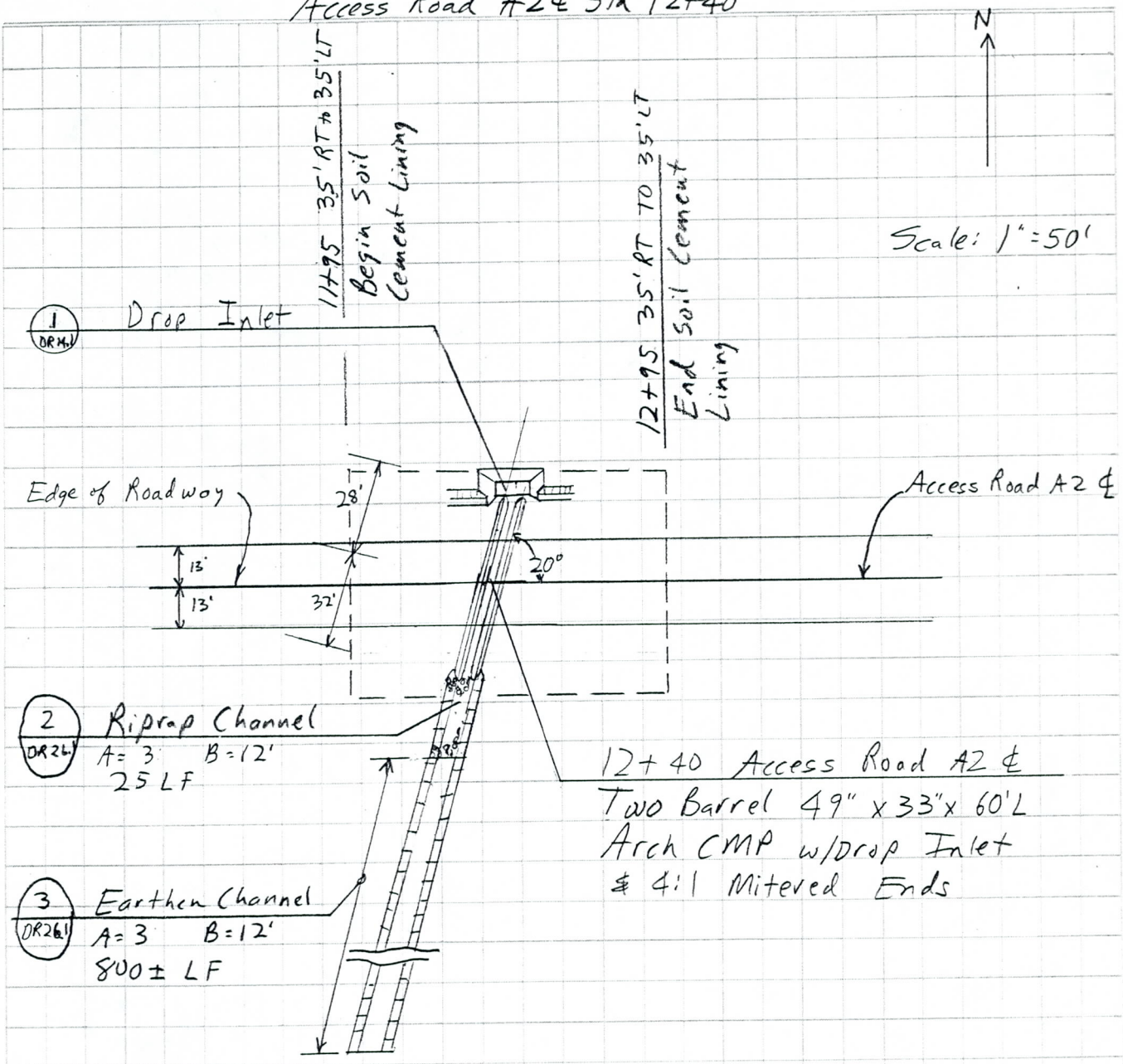
SHEET NO. _____ OF _____

DATE 9-8-91

COMPUTATIONS FOR Culvert 47 Plan

BY DFP CHKD RJT

Access Road A2 ℄ Sta 12+40



47 Pipe Culvert Plan

Sta. 12+40 Access Road A2

See Profile Dwg DR-14.1

SVERDRUP

JOB 40477 Toyota SHEET NO. 8 OF

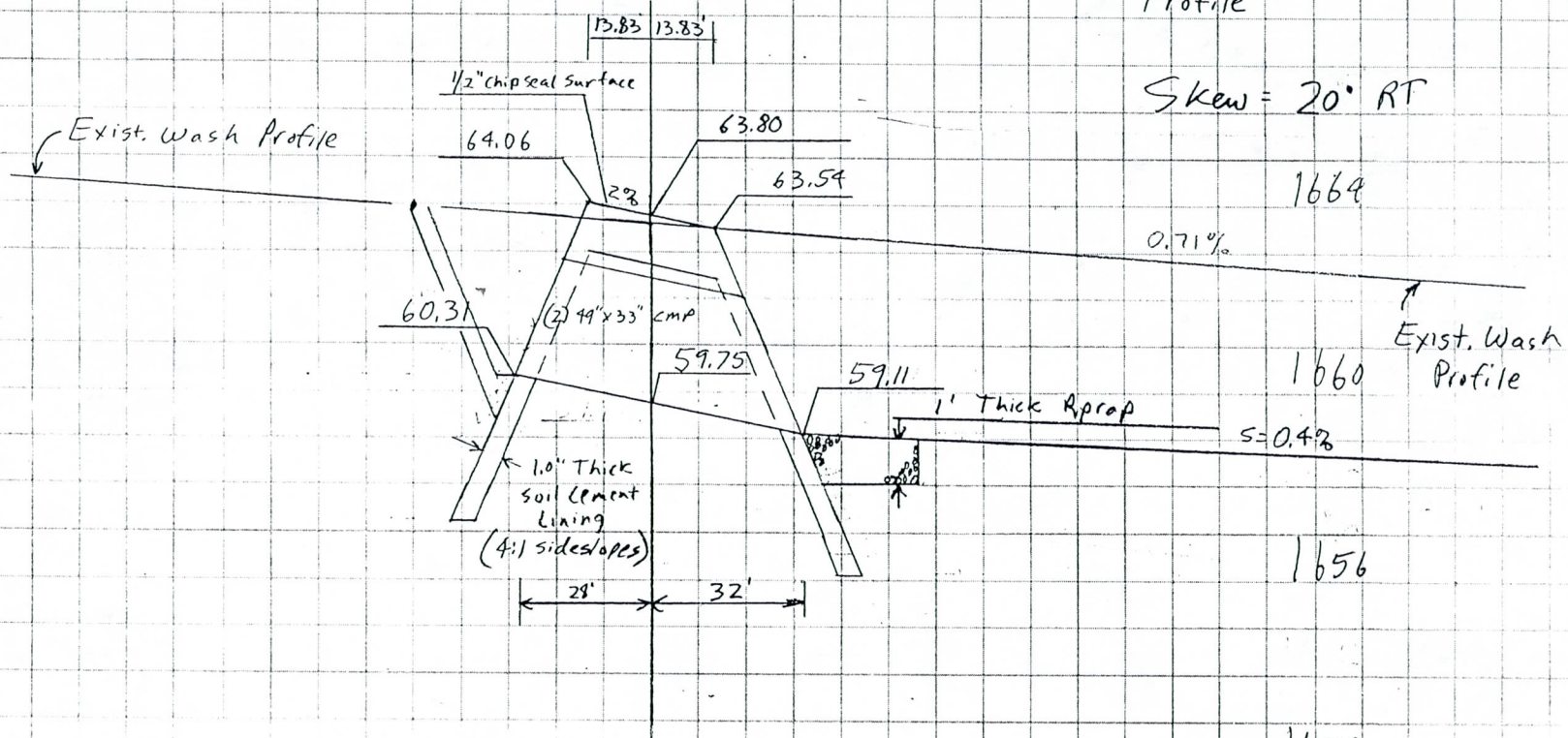
COMPUTATIONS FOR Culvert 47 Profile DATE 8-28-91

Access Road A2 Sta 12+40 BY DFP CHKD BVT

Culvert 47 | 47

Profile

Skew = 20° RT



Access Road A2
Sta. 12+40

47 Pipe Culvert Profile
Sta 12+40 Access Road A2
See Plan Dwg. DR-6.1

Scale:
Horiz: 1" = 40'
Vert: 1" = 4'

SECTION NUMBER A1 1240 8/30/91

Channel Slope: 0.0071 ft./ft.

CROSS SECTION DATA:

OFFSET	1100	1200	1225	1250	1275	1300	1350
ELEV.	65.15	64.05	63.85	63.8	63.9	64.16	64.81
N	N/A	0.025	0.025	0.025	0.025	0.025	0.025

STAGE-DISCHARGE DATA:

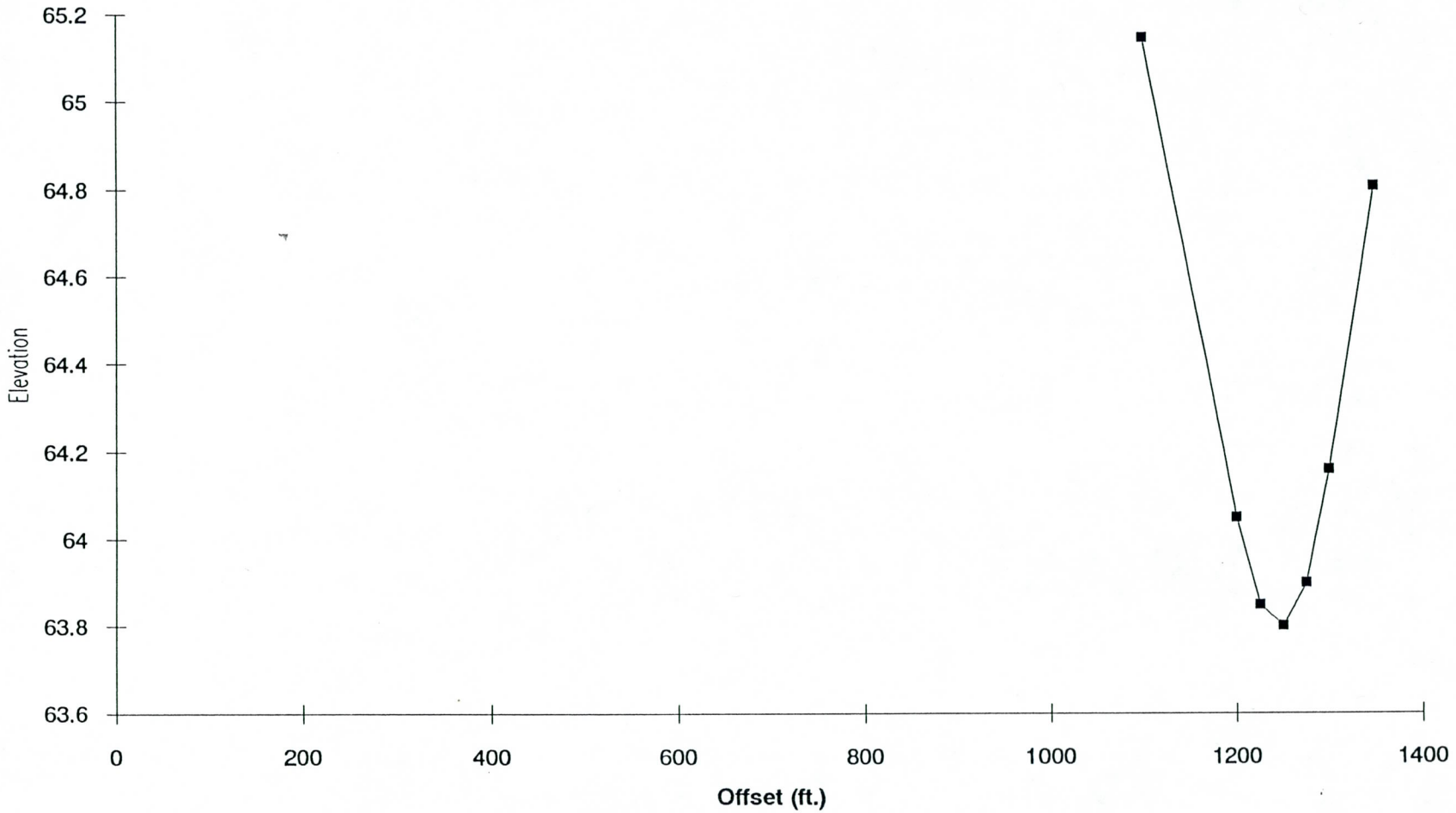
STAGE:	63.8										
WET PER.		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
AREA		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYD.RAD.		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Q		0	0	0	0	0	0	0	0	0	0	0
STAGE:	63.9										
WET PER.		0.0	6.3	31.3	56.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
AREA		0.0	0.2	2.0	3.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYD.RAD.		0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Q		0	0	0	2	0	0	0	0	0	0	0
STAGE:	64										
WET PER.		0.0	18.8	43.8	68.8	78.4	0.0	0.0	0.0	0.0	0.0	0.0
AREA		0.0	1.4	5.8	9.5	10.0	0.0	0.0	0.0	0.0	0.0	0.0
HYD.RAD.		0.0	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Q		0	0	0	0	13	0	0	0	0	0	0
STAGE:	64.1										
WET PER.		4.6	29.6	54.6	79.6	98.8	0.0	0.0	0.0	0.0	0.0	0.0
AREA		0.1	3.9	10.7	17.0	18.9	0.0	0.0	0.0	0.0	0.0	0.0
HYD.RAD.		0.0	0.1	0.2	0.2	0.2	0.0	0.0	0.0	0.0	0.0	0.0
Q		0	0	0	0	31	0	0	0	0	0	0
STAGE:	64.2										
WET PER.		13.6	38.6	63.6	88.6	113.6	116.7	0.0	0.0	0.0	0.0	0.0
AREA		1.0	7.3	16.6	25.4	29.6	29.7	0.0	0.0	0.0	0.0	0.0
HYD.RAD.		0.1	0.2	0.3	0.3	0.3	0.3	0.0	0.0	0.0	0.0	0.0
Q		0	0	0	0	0	60	0	0	0	0	0
STAGE:	64.3										
WET PER.		22.7	47.7	72.7	97.7	122.7	133.5	0.0	0.0	0.0	0.0	0.0
AREA		2.8	11.6	23.5	34.7	41.5	42.2	0.0	0.0	0.0	0.0	0.0
HYD.RAD.		0.1	0.2	0.3	0.4	0.3	0.3	0.0	0.0	0.0	0.0	0.0

SECTION NUMBER A1 1240 8/30/91

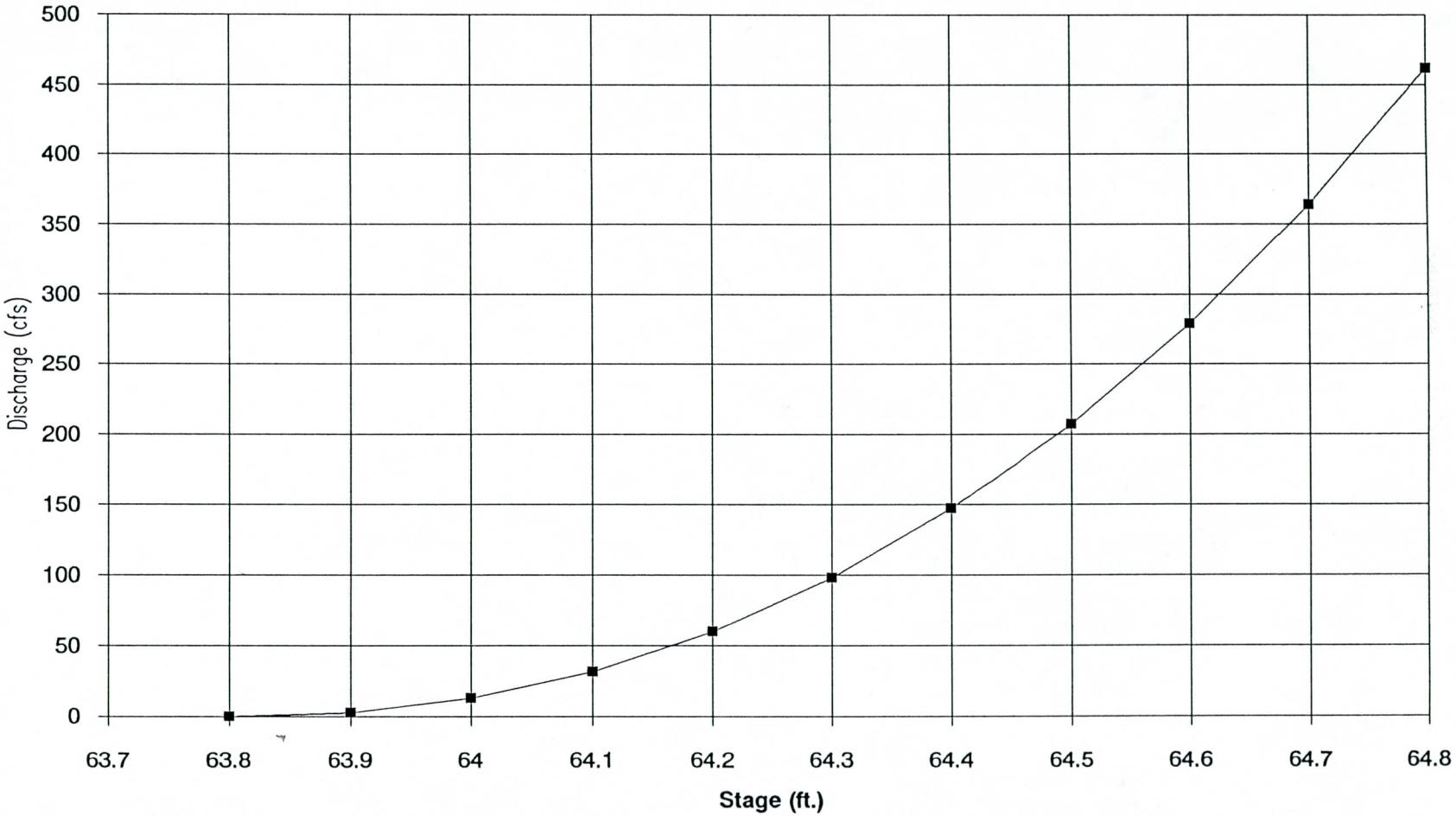
STAGE:	64.4										
WET PER.		31.8	56.8	81.8	106.8	131.8	150.3	0.0	0.0	0.0	0.0	0.0
AREA		5.6	16.8	31.2	44.9	54.2	56.4	0.0	0.0	0.0	0.0	0.0
HYD.RAD.		0.2	0.3	0.4	0.4	0.4	0.4	0.0	0.0	0.0	0.0	0.0
Q		0	0	0	0	0	147	0	0	0	0	0
STAGE:	64.5											
WET PER.		40.9	65.9	90.9	115.9	140.9	167.1	0.0	0.0	0.0	0.0	0.0
AREA		9.2	23.0	39.8	56.1	67.8	72.3	0.0	0.0	0.0	0.0	0.0
HYD.RAD.		0.2	0.3	0.4	0.5	0.5	0.4	0.0	0.0	0.0	0.0	0.0
Q		0	0	0	0	0	207	0	0	0	0	0
STAGE:	64.6											
WET PER.		50.0	75.0	100.0	125.0	150.0	183.9	0.0	0.0	0.0	0.0	0.0
AREA		13.7	30.0	49.4	68.1	82.4	89.8	0.0	0.0	0.0	0.0	0.0
HYD.RAD.		0.3	0.4	0.5	0.5	0.5	0.5	0.0	0.0	0.0	0.0	0.0
Q		0	0	0	0	0	279	0	0	0	0	0
STAGE:	64.7											
WET PER.		59.1	84.1	109.1	134.1	159.1	200.6	0.0	0.0	0.0	0.0	0.0
AREA		19.2	38.0	59.8	81.1	97.8	109.0	0.0	0.0	0.0	0.0	0.0
HYD.RAD.		0.3	0.5	0.5	0.6	0.6	0.5	0.0	0.0	0.0	0.0	0.0
Q		0	0	0	0	0	364	0	0	0	0	0
STAGE:	64.8											
WET PER.		68.2	93.2	118.2	143.2	168.2	217.4	0.0	0.0	0.0	0.0	0.0
AREA		25.6	46.8	71.2	94.9	114.2	129.9	0.0	0.0	0.0	0.0	0.0
HYD.RAD.		0.4	0.5	0.6	0.7	0.7	0.6	0.0	0.0	0.0	0.0	0.0
Q		0	0	0	0	0	462	0	0	0	0	0

W.S. Elev.	63.8	63.9	64	64.1	64.2	64.3	64.4	64.5	64.6	64.7	64.8
Q	0	2	13	31	60	98	147	207	279	364	462
A	0.0	3.3	10.0	18.9	29.7	42.2	56.4	72.3	89.8	109.0	129.9
V	0.0	0.8	1.3	1.7	2.0	2.3	2.6	2.9	3.1	3.3	3.6

Cross Section - A1 1240



Stage Discharge - A1 1240

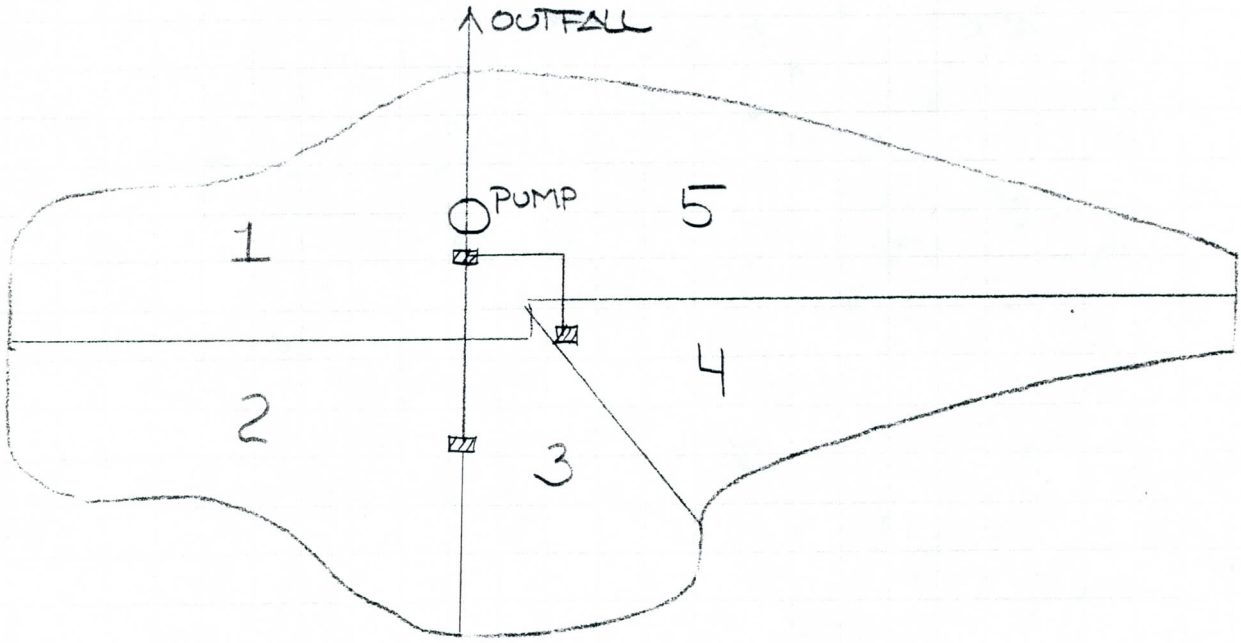


SVERDRUP

JOB TOYOTA # 40477 SHEET NO. 1 OF 31

DATE 7/91

COMPUTATIONS FOR STEEP GRADES DRAIN. BY BSW CHKD RJT



OBJECTIVES:

DESIGN LIFT STATION FOR 2 YR. STORM CAPACITY.

DESIGN GUTERS & CONC. DITCHES FOR 10 YEAR SPREAD, CHECK FOR PONDING @ 50 YR.

BASIN	AREA FT²	AREA ACRES
1	26,115	.600
2	24,122	.554
3	13,257	.304
4	16,335	.375
5	34,545	.793

TOTAL AREA = 2.626 ACRES

TOTAL PAVED AREA (C=.95) = 0.758 ACRES

EARTH SURFACE AREA (C=.40) = 2.626 - .758 = 1.868

SVERDRUP

JOB TOYOTA 40477 SHEET NO. 2 OF 31

DATE 7/91

COMPUTATIONS FOR STEEP GRADES DRAIN. BY BSW CHKD RJT

$$T_c = 11.4\, L^{.5}\, k_b^{0.52}\, S^{-0.31}\, i^{-0.38} \quad (\text{EQ 3.2 HDMMC})$$

USE SAME T_c FOR ALL BASINS USING LARGEST BASIN AS A TRIAL (BASIN 5)

$L = 400$ FT $= .0757$ MILE

$k_b = m \log A + b$ (TABLE 3.1, HDMMC)

$m = -0.01375$

$b = 0.08$

$A = 0.793$ ACRES

$= 0.0814$

$S = 32'/.0757$ MILE $= 422$ '/MILE

$i =$ FOR 10 YR, 5 MIN DURATION (PHX METRO AREA)

FROM FIG 3.2 & EQ 3.3 (HDMMC) $= 5.9 \Rightarrow \left[i_{PHX} \frac{P_{10}^6}{2.07} \right] = 5.9 \left(\frac{2.15}{2.07} \right) =$

i (10 YR) $= 6.1$ IN/HR (ADJUSTED TO NON-METRO AREA)

FOR 50 YR, 5 MIN DURATION

$= 8.0 \frac{(2.15)}{2.07}$ FROM FIG 3.2 & EQUATION 3.3 (HDMMC)

i (50 YR) $= 8.3$ IN/HR

$T_{c\ 10\text{YR}} = 3.9$ MIN

USE $T_c = 5$ MIN

$T_{c\ 50\text{ YR}} = 3.5$ MIN

SVERDRUP

JOB TOYOTA #40477 SHEET NO. 3 OF 31

DATE 7/91

COMPUTATIONS FOR STEEP GRADES DRAIN BY BSW CHKD RJT

$T_c = 11.4\ L^{.5}\ t_b^{0.52}\ S^{-0.31}\ i^{-0.38}$ (EQ 3.2, HDMMC)

USE LARGEST BASIN AS CRITERIA (#5)

$L = 400^{FT} = .0757$ MILE

$t_b = m \log A + b$ (TABLE 3.1, HDMMC)

$m = -.01375$
$b = 0.08$
$A = 0.793$ ACRES

$t_b = 0.0814$

$S = 32'/.0757\text{ MILE} = 422'/\text{MILE}$

i = FOR 2 YR, 5 MIN DURATION (EQ 3.3, HDMMC)

(FROM FIG 3.2 HDMMC)

$i_{PHX} = 3.8^{IN/HR}$ $\left[i_{TOT.} = \frac{i_{PHX}\ P_{10}^6}{2.07} \right] \Rightarrow 3.8 \left(\frac{2.15}{2.07} \right)$

i (2 YR) $i_{TOT.} = 3.95^{IN/HR}$ ADJUSTED TO NON-METRO AREA).

$T_c = 11.4\ (.0757)^{.5}\ (0.0815)^{0.52}\ (422)^{-0.31}\ (3.95)^{-0.38}\ 60\ \text{MIN/HR}$

$= 4.65$ MIN. USE 5 MIN = T_c.

$Q = C\ i\ A$ $C = 0.95$ (ASPHALT)
0.40 (3:1 GRADE)

SVERDRUP

JOB TOYOTA #40477 SHEET NO. 4 OF 31

DATE 7/91

COMPUTATIONS FOR STEEP GRADES DRAIN BY BSW CHKD RJT

$$C_{AVG} = \frac{(.758)(.95) + (1.868)(.40)}{2.626}$$

$$= 0.56$$

$i \Rightarrow$ 2 YR = 3.95 IN/HR

10 YR = 6.1 IN/HR

50 YR = 8.3 IN/HR

$Q = CiA$

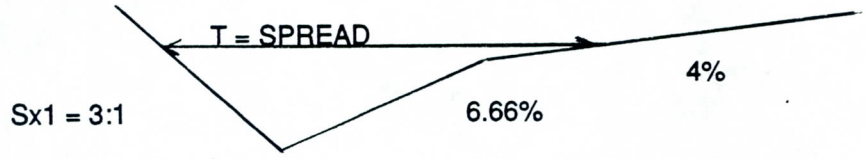
BASIN	AREA	Q_2	Q_{10}	Q_{50}
1	.600	1.327 cfs	2.050 cfs	2.789 cfs
2	.554	1.225	1.892	2.575
3	.304	0.672	1.038	1.413
4	.375	0.830	1.281	1.743
5	.793	1.754	2.709	3.686
		5.809	8.970	12.206

PG 5/31, B&W
RJT

SPREAD CALCULATIONS:

$$Q = \frac{0.56 * Sx^{1.67} * S^{0.5} * T^{2.67}}{n}$$ (EQ. 4, HEC 12)

TYPICAL SECTION:



$$Sx = \frac{(Sx1)(Sx2)}{Sx1 + Sx2}$$

Sx 1 = .333
Sx 2 = VARIES, AND WILL BE SHOWN AS A WEIGHTED AVERAGE OF 6.66% & 4%
n = 0.016
S = VARIES

LOCATION	DRAIN AREA (ACRES)	Q (10 YR) (CFS)	SLOPE (FT/FT)	Sx 2	Sx	SPREAD "T" (FT)
STA 6+15, 42' LT	0.191	0.652	0.2500	0.067	0.056	1.78
STA 5+30, 42' LT	0.38	1.298	0.2500	0.067	0.056	2.30
STA 4+75, 46' LT (NORTH)	0.554	1.892	0.0050	0.053	0.046	6.23
STA 4+75, 46' LT (SOUTH)	0.304	1.038	0.0050	0.056	0.048	4.83
STA 2+80, 20' LT	0.183	0.625	0.0800	0.067	0.056	2.17
STA 3+90, 20' LT	0.348	1.189	0.0800	0.067	0.056	2.76
STA 4+30, 20' LT	0.375	1.281	0.0050	0.056	0.048	5.22
STA 2+80, 20' RT	0.273	0.933	0.0800	0.067	0.056	2.52
STA 3+90, 20' RT	0.449	1.534	0.0800	0.067	0.056	3.03
STA 4+75, 46' RT (SOUTH)	0.793	2.709	0.0050	0.051	0.044	7.27
STA 4+75, 46' RT (NORTH)	0.600	2.050	0.0050	0.053	0.046	6.42
STA 5+30, 42' RT	0.372	1.271	0.2500	0.067	0.056	2.28
STA 6+15, 42' RT	0.191	0.652	0.2500	0.067	0.056	1.78

LENGTH OF SLOTTED DRAIN REQUIRED ("L"):

$$L = k * Q^{0.42} * S^{0.3} * (1 / (n * Sx))^{0.6}$$ (EQ. 13, HEC 12)

with clogging factor = 50 %: L (W/CLOGGING) = L (DESIGN) / 50% (k = 0.6)

BASIN NO.	Q (10 YR) (CFS)	SLOPE (FT/FT)	Sx	L (DESIGN) (FT)	L (W/CLOG) (FT)	LENGTH INSTALLED (FT) *
1	2.050	0.005	0.046	12.55	25.1	25
2	1.892	0.005	0.046	12.13	24.3	25
3	1.038	0.005	0.048	9.19	18.4	20
4	1.281	0.005	0.048	10.04	20.1	20
5	2.709	0.005	0.044	14.49	29.0	30

* A DOWN STREAM CATCH BASIN WILL BE PLACED AT THE END OF EACH SLOTTED DRAIN SECTION

SVERDRUP

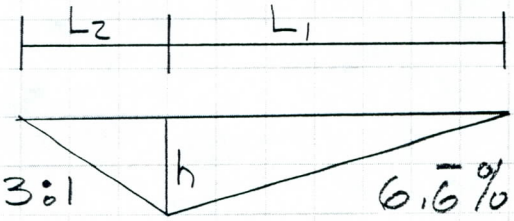
JOB TOYOTA #40477 SHEET NO. 6 OF 31

DATE 7/91

COMPUTATIONS FOR STEEP GRADES DRAIN. BY BSW CHKD RJT

DRAINAGE DITCH DETAIL (IN NON-PAVED AREA)

MAX SPREAD = 2.30'



$L_1 + L_2 = 2.30'$

$L_1 = \frac{0.128}{.066} = 1.92'$

$2.30 = \frac{h}{.06} + \frac{h}{.333} = 18.00\,h$

$L_2 = \frac{0.128}{.333} = 0.38'$

$h = 0.128$ FT

USE ADOT STD TYPE 'B' GUTTER

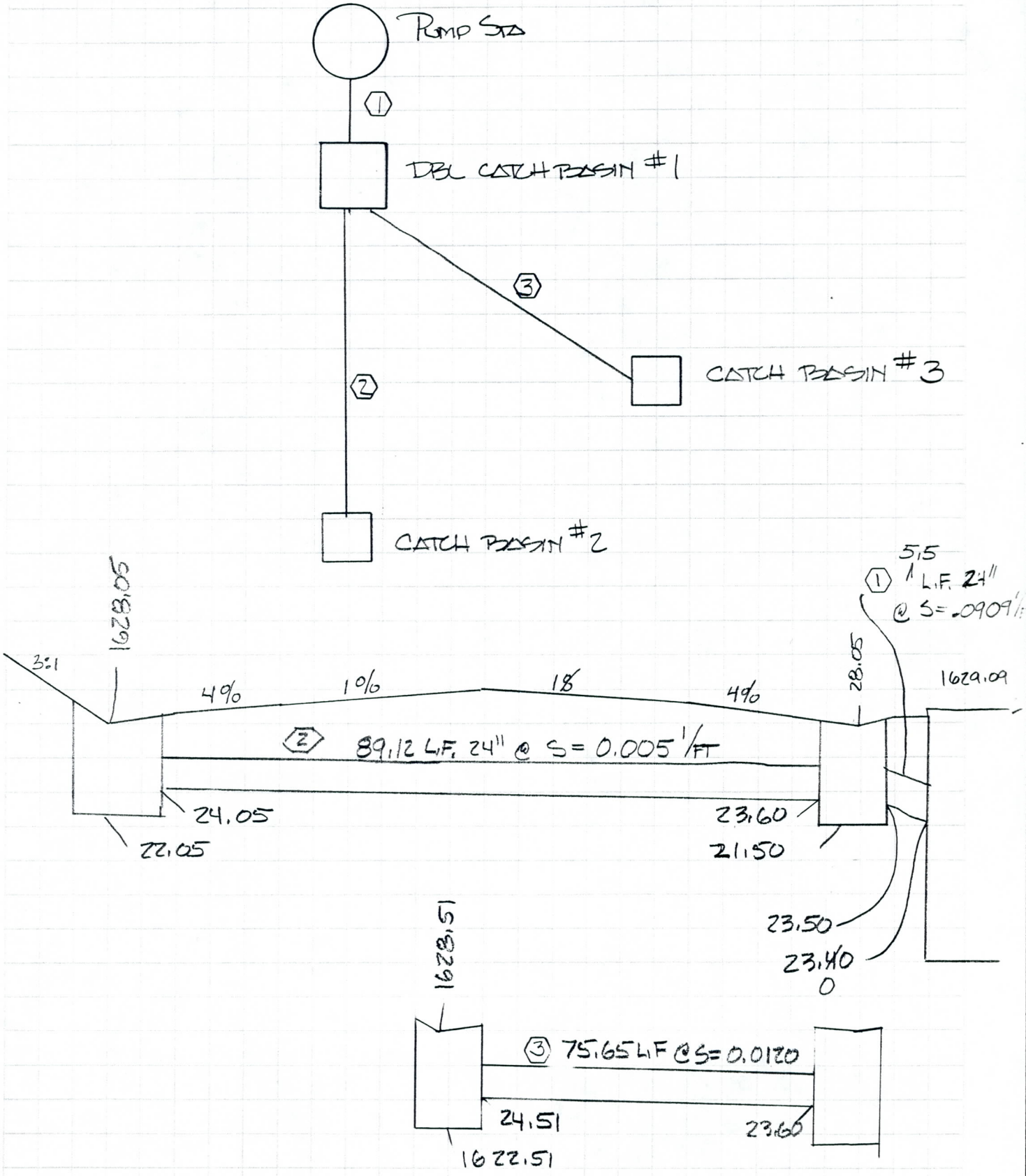
STD C-5.10

SVERDRUP

JOB TOYOTA 40477 SHEET NO. 7 OF 31

DATE 7/91

COMPUTATIONS FOR STEEP GRADES DRAIN BY BSW CHKD RJT

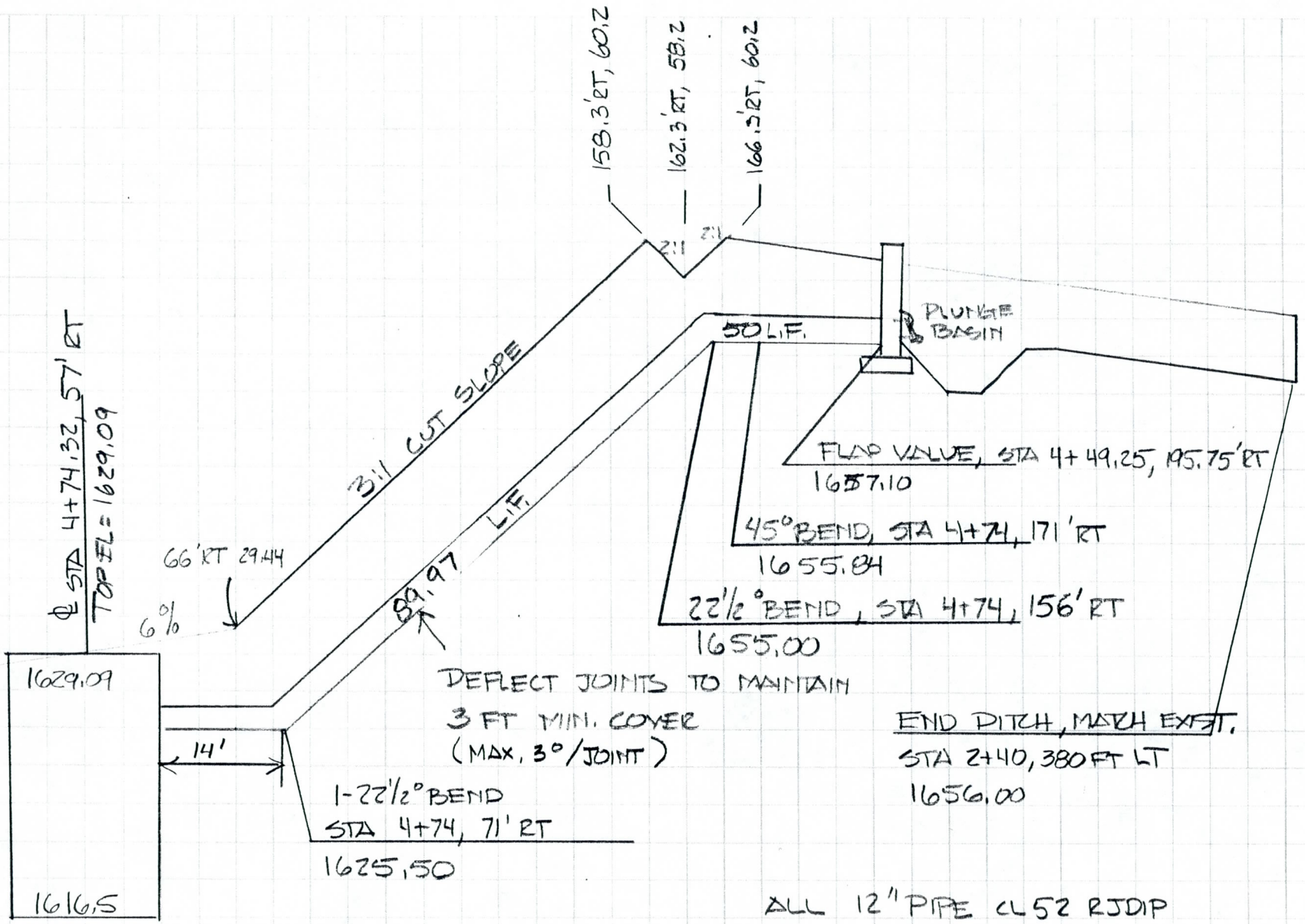


SVERDRUP

JOB TOKOTA 40477 SHEET NO. 8 OF 31

COMPUTATIONS FOR STEEP GRADE OUTFALL DATE 7/91

BY BSW CHKD RVT



SVERDRUP

JOB TOYOTA 40477 SHEET NO. 9 OF 31

DATE 7/91

COMPUTATIONS FOR STEEP GRADE D. ELEV. BY BSW CHKD RJT

CATCH BASIN #1

STA 4+74.32, 46.06' RT

GRATE EL = 1629.00 - (32.5)(.01) - (11.56)(.04) - 2"

= 1628.05

INV IN ELEV = 1623.60

INV OUT ELEV = IN ELEV - 0.1 = 1623.50

FLOOR ELEV = 1621.50

CATCH BASIN #2

ST 4+74.32, 46.06' LT

GRATE EL = CB# 1 = 1628.05

INV OUT ELEV = GRATE - 2' COVER - 24" PIPE = 1624.05

SLOPE TO CB# 1 = 0.005 '/FT (MIN = .0004 '/FT)

LENGTH (℄ TO ℄) TO CB# 1 = 92.12 FT = 89.12' (FACE-FACE)

FLOOR ELEV = INV OUT ELEV - 2.0' = 1622.05'

SVERDRUP

JOB TOYOTA 40477 SHEET NO. 10 OF 31

DATE 7/91

COMPUTATIONS FOR STEEP GRADES DRAIN BY BSW CHKD RJT

CATCH BASIN # 3

STA 4+29.82, 20' LT

GRATE ELEV = 1628.8808 + 10(.01) - 7.5(.04) - 2"

= 1628.51

INV OUT ELEV = GRATE - 2' COVER - 24" PIPE = 1624.51

LENGTH (INSIDE FACE TO FACE) TO CB#1 = 75.65 FT

SLOPE TO CB#1 = $\frac{1624.51 - 1623.60}{75.65} = 0.0120$ '/FT

FLOOR ELEV = INV OUT - 2' = 1622.51

SVERDRUP

JOB TOYOTA 40477 SHEET NO. 11 OF 31

COMPUTATIONS FOR STEEP GRADES DRAIN DATE 7/91 BY BSW CHKD RTT

LIFT STATION PUMP SIZE

Q (2-YEAR) $= (.56)(3.95)(2.626) = 5.809$ cfs

$= 2{,}607$ gpm

FOR 2 PUMPS $\Rightarrow$ 1,303 gpm.

SIZE DISCHARGE PIPE

PUMP DISCH.:

$Q = VA = 2.904$ cfs

$2.904 = (8\ ^{1}/_{SEC})\left(\frac{\pi}{4} D^2\right)$

$D = \left[\frac{2.904\ (4)}{\pi\ (8)}\right]^{.5}$

FOR FLUID VELOCITY, ASSUME 8'/SEC

$= .68' \cong 8$ IN. DIA PIPE

SYSTEM DISCH.:

$5.809 = (8)\left(\frac{\pi}{4} D^2\right)$

$D = \left[\frac{5.809\ (4)}{\pi\ (8)}\right]^{.5}$

$= .96' \approx 12$ IN DIA PIPE.

ELEVATION HEAD $= 1658.00 - 1618 = 40'$

VELOCITY HEAD $= V^2/2g = \frac{(8)^2}{2(32.2)} = 1'$

SVERDRUP

JOB Toyota 40477 SHEET NO. 12 OF 31

DATE 7/91

COMPUTATIONS FOR STEEP GRADES DRAIN BY BAW CHKD RJT

PIPE (PUMP DISCHARGE) (USING 8-INCH)

PIPE	20
CHECK VALVE	7.4
GATE VALVE	2.7
90° BEND (2)	2.0
45° BEND (2)	12.6
TEE	20.0
	149.3'

× 150.0 FT 8 IN PIPE

PIPE (SYSTEM DISCHARGE) (USING 12-INCH DIP)

PIPE	140
45° BEND (2)	19.4
FLAP GATE	— .5 FT
	159.4

× 160 FT 12" DIP.

FRICTION HEAD (USING HAZEN-WILLIAMS)

$$h_f = 3.022\, v^{1.85} L / C^{1.85} D^{1.165}$$

FOR 8" DISCHARGE ⇒ $h_f = 3.022 (8)^{1.85} (150) / (100)^{1.85} (8/12)^{1.165}$

$= 6.80$ FT

FOR 12" OUTFALL ⇒ $h_f = 3.022 (8)^{1.85} (160) / (100)^{1.85} (1)$

$= 4.52$ FT + .5 FT

$= 5.02$ FT

TOTAL HEAD ⇒ 5.02 + 6.80 + 1 + 40 = 52.82 ⇒ USE 53'

SVERDRUP

JOB Toyota 40477 SHEET NO. 13 OF 31

COMPUTATIONS FOR Steep Grades Drain DATE 7/91 BY BSW CHKD RJT

WET WELL SIZING:

PUMP CAN HANDLE UP TO 15 STARTS/HOUR

VOLUME = $\phi q/4$ WHERE ϕ = CYCLE TIME (MIN)

q = PUMP CAPACITY

$\Rightarrow$ IF WE USE 12 STARTS/HOUR, ϕ = 5 MIN

$= 5\frac{(1300\ gpm)}{4} = 1625\ gal = 217.25\ FT^3$

USING 8' DIA WETWELL, $A = \frac{1}{4}\pi(8)^2 = 50.27\ FT^2$

STORAGE REQ'D FOR 1ST PUMP ON SWITCH:

$H = \frac{217.25}{50.27} = 4.321\ FT \Rightarrow$ USE 5 FT

$=$ (1880 GAL.)

MIN. WATER ELEVATION FOR #3170 PUMP $\cong$ 18 IN = 1.5 FT.

SECOND PUMP ON SWITCH 2 FT ABOVE 1ST ON SWITCH.

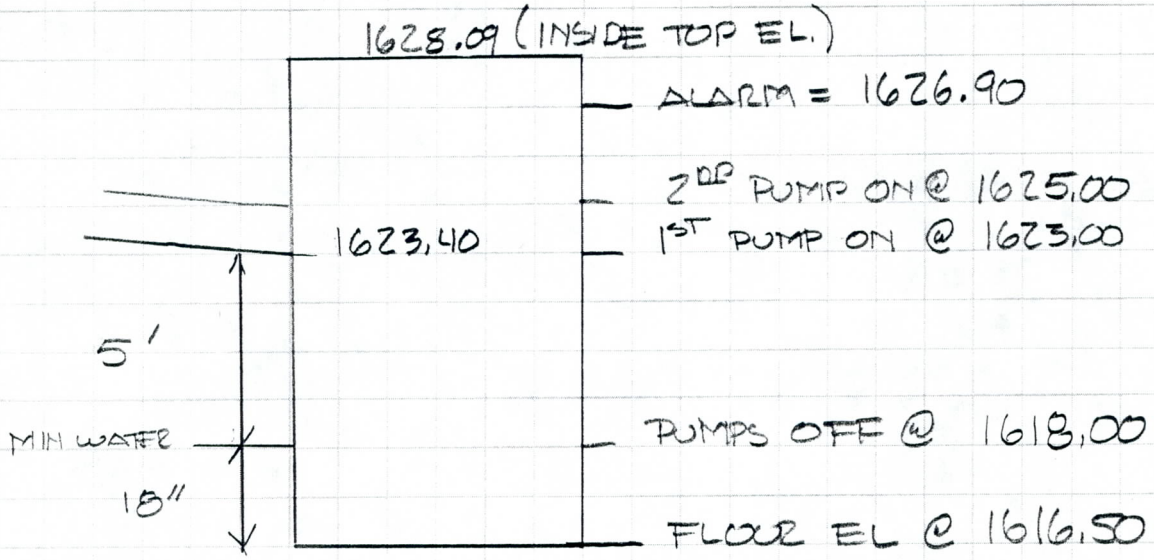
ALARM ON 1 FOOT BELOW TOP SLAB ELEVATION

SVERDRUP

JOB TOYOTA 40477 SHEET NO. 14 OF 31

COMPUTATIONS FOR STEEP GRADES DRAIN DATE 7/91

BY BSW CHKD RJT



STORAGE AFTER 2ND PUMP ON, BEFORE FLOODING:

2ND PUMP ON @ 1625.00

LOW GRATE ELEV. = 1623.05

2 SINGLE 4X4 CATCH BASINS = (3X3X3')2 = 54 FT^3

1 DOUBLE 4X7.5 CATCH BASINS (3X6.5X3) = 58.5 FT^3

PIPE: 89 L.F. OF 24" PIPE, 1/3 REMAINING $\cong$ 93 FT^3

75 L.F. OF 24" PIPE, 1/3 REMAINING $\cong$ 78 FT^3

120 L.F. OF 18" SLOTTED DRAIN = 212 FT^3

495.5 FT^3

$\cong$ 3700 GAL

SVERDRUP

JOB TOYOTA 40477 SHEET NO. 15 OF 31

DATE 7/91

COMPUTATIONS FOR STEEP GRADES DRAIN BY PSW CHKD RJT

TOTAL SYSTEM VOLUME BEFORE PONDING:

PONDING ELEVATION: 1628.05

WETWELL: 10 FT (50.27) = 502.7 FT^3

SINGLE CATCH BASIN #2
= 3×3×(28.05 − 22.05) = 54 FT^3

SINGLE CATCH BASIN #3
= 3×3×(28.05 − 22.51) = 49.8 FT^3

DBL CATCH BASIN #1
= 3×6.5×(28.05 − 21.50) = 127.7 FT^3

PIPE: = (75.65 + 89.12) $\frac{1}{4}\pi(2)^2$ = 517.6 FT^3

SLOTTED DRAIN: (120) $\frac{1}{4}\pi(1.5)^2$ = 212.1 FT^3

1,463.9 FT^3

≈ 10,950 GAL

NOTE: 5 FT OF WETWELL & 2FT OF EACH CATCH BASIN VOLUME COULD BE REMOVED FROM THE TOTAL DUE TO PUMP CYCLE & SEDIMENTATION

STORAGE VOLUME (USE) = 1,463.9 − (2×3×3)(2) − (2×3×6.5) − 5(50.27)

1,137.5 FT^3

≈ 8,500 GAL.

PUMP CRITERIA

1 PUMP ON:

HEAD = 53 FT TO 48 FT
Q REQ'D = 1,303 gpm / PUMP

USE FLYGT PUMP

CP-3170 w/ IMPELLER 443

@ HEAD = 53 FT, Q = 1200 gpm

@ HEAD = 48 FT, Q = 1300 gpm

2 PUMPS ON:

HEAD = 46 FT TO 43 FT

USING FLYGT PUMP # CP-3170 w/ 443 IMPELLER

@ HEAD = 46 FT, Q = 1350 gpm

@ HEAD = 43 FT, Q = 1425 gpm

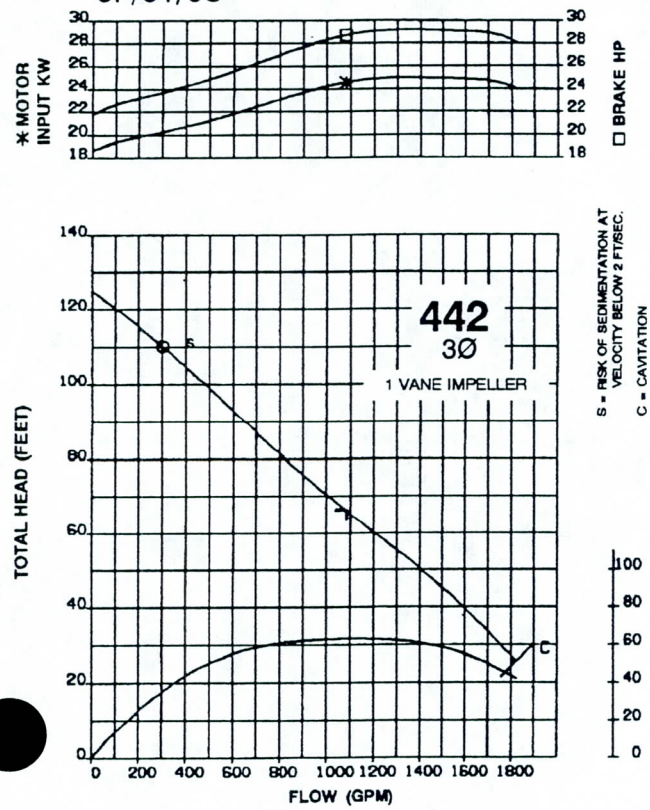
FOR PONDING VOLUME CALCULATIONS:

FOR 1 PUMP ON, USE Q = 1300 gpm / EACH

FOR 2 PUMPS ON, USE Q = 1400 gpm / EACH

SECTION	PAGE	WASTEWATER	IMPELLER PERFORMANCE CURVES	C-3170
3	1			
SUPERSEDES	ISSUED 6/90			

CP/CT/CS



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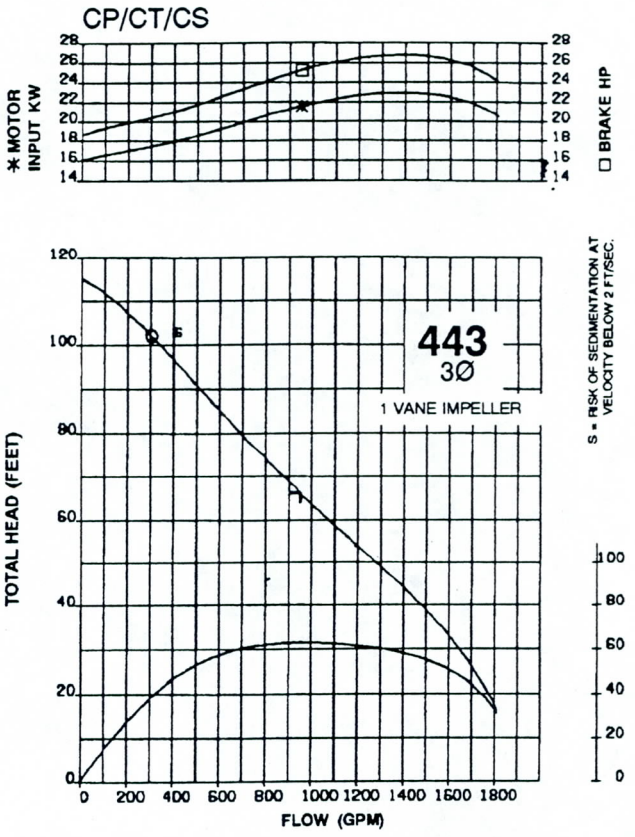

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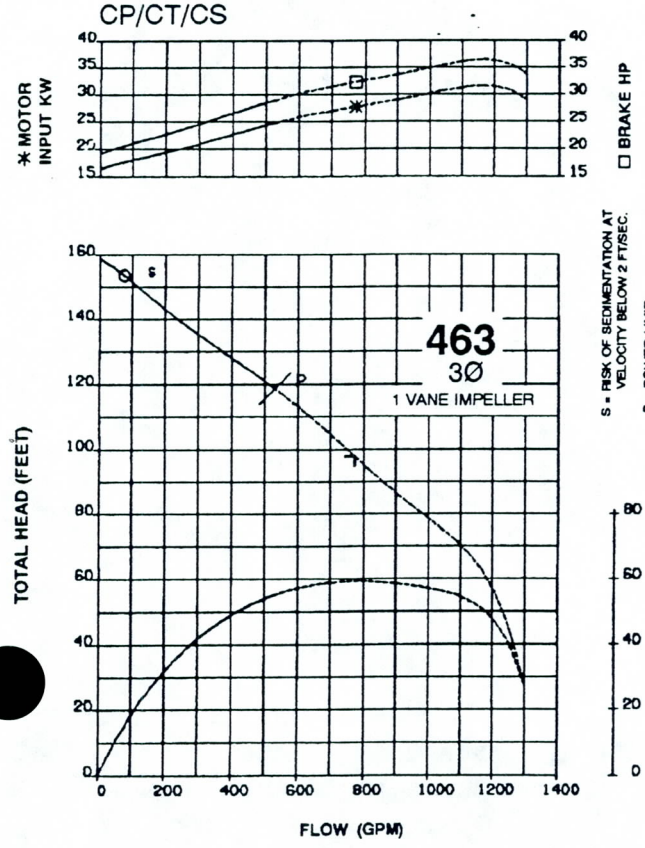

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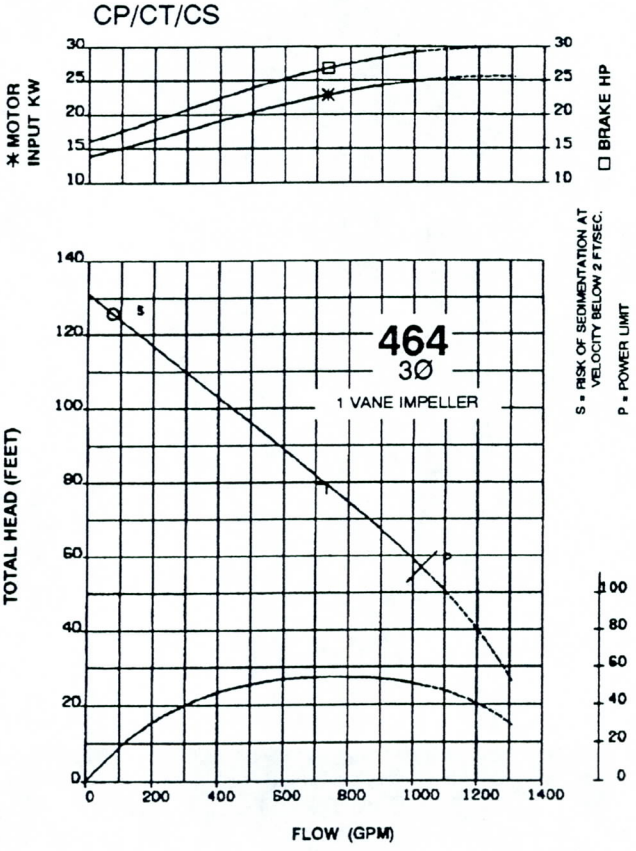


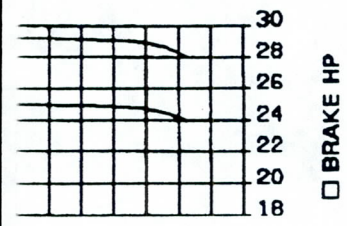
18/31

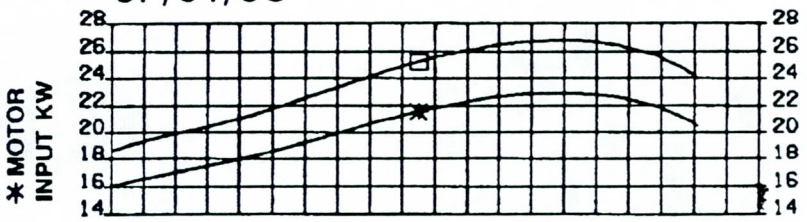
EWATER

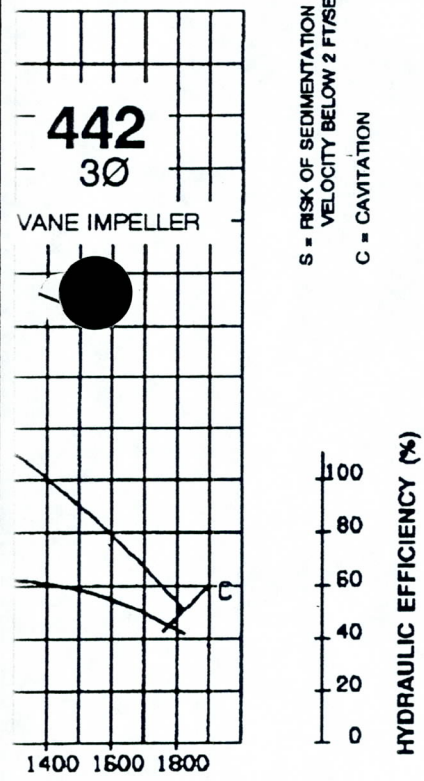
IMPELLER PERFORMANCE CURVES

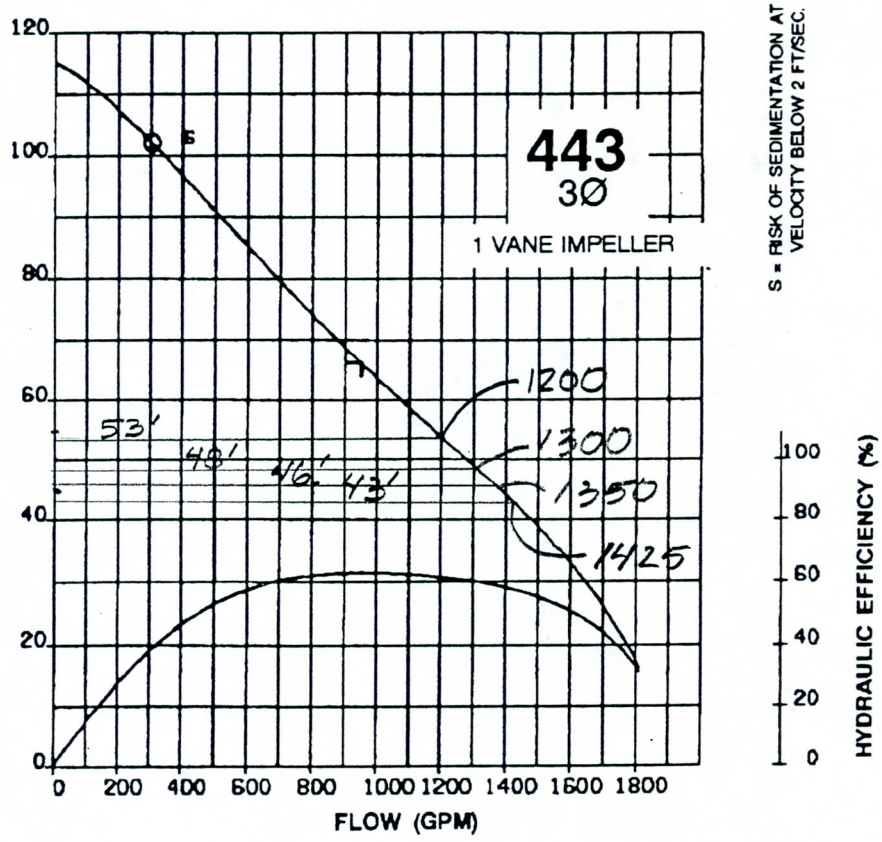
C-3170

CP/CT/CS









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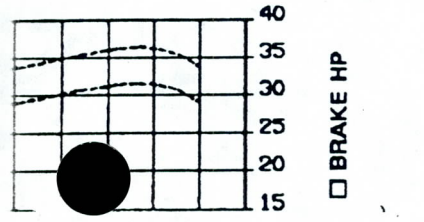

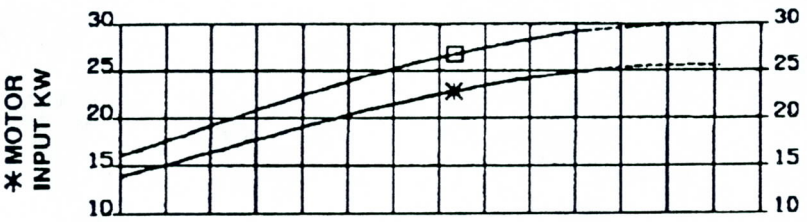

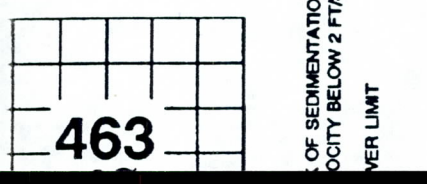

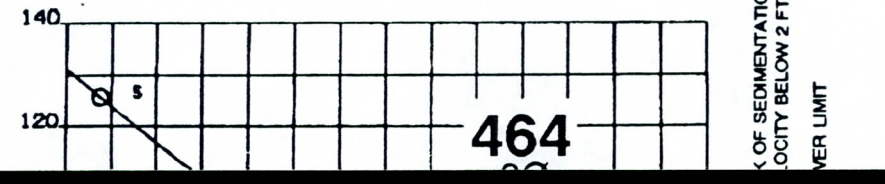

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SUBJECT DEPTH-DURATION FREQUENCY TABLE
PROJECT 80102.00
FILE NO. 002
COMPUTED TRL CHECKED
DATE 3/29/91 PAGE 1 OF 2 PAGES

USE : MARICOPA CO. HYDROLOGIC DESIGN MANUAL

RETURN FREQUENCY	6-HR	24 HR
2-YR	1.3	1.55
5-YR	1.8	2.15
10-YR	2.1	2.65
25-YR	2.7	3.3
50-YR	3.0	3.8
100-YR	3.3	4.2

$$Y_2 = -0.011 + 0.942(X_1)\left(\frac{X_1}{X_2}\right)$$

$$Y_{100} = 0.494 + 0.755(X_3)\left(\frac{X_3}{X_4}\right)$$

$$\Rightarrow Y_{2_{1hr}} = -0.011 + 0.942(1.3)\left(\frac{1.3}{1.55}\right) = 1.016$$

$$Y_{100_{1hr}} = 0.494 + 0.755(3.3)\left(\frac{3.3}{4.2}\right) = 2.45$$

SUBJECT _____ PROJECT _____

_____ FILE NO. _____

COMPUTED _____ CHECKED _____ DATE _____ PAGE 2 OF 2 PAGES

TWO HOUR DEPTHS

2 YR - 2 hour = 0.341 (1.3) + 0.659 (1.016) = 1.11

100 YR - 2 hour = 0.341 (3.3) + 0.659 (2.45) = 2.74

THREE HOUR DEPTHS

2-YR, 3 hour = 0.569 (1.3) + 0.431 (1.016) = 1.18

100-yr, 3 hour = 0.569 (3.3) + 0.431 (2.45) = 2.93

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SUBJECT AERIAL REDUCTION OF PRECIP.

PROJECT TOYOTA

FILE NO. 80102.00

COMPUTED _____ CHECKED _____

DATE _____ PAGE ___ OF ___ PAGES

6 HOUR PRECIPITATION

BASIN AREA	REDUCTION FACTOR	100 YR	50 YR	25 YR	10 YR	5 YR	2 YR
0.01	0.0	3.30	3.0	2.7	2.1	1.8	1.3
0.5	0.9933	3.28	2.98		2.09		
2.8	0.9788	3.23	2.94		2.06		
16.0	0.9212	3.04	2.76		1.93		
90.0	0.8091	2.67	2.42		1.70		
[illegible]0	0.57	1.88	1.71		1.20		

22/31

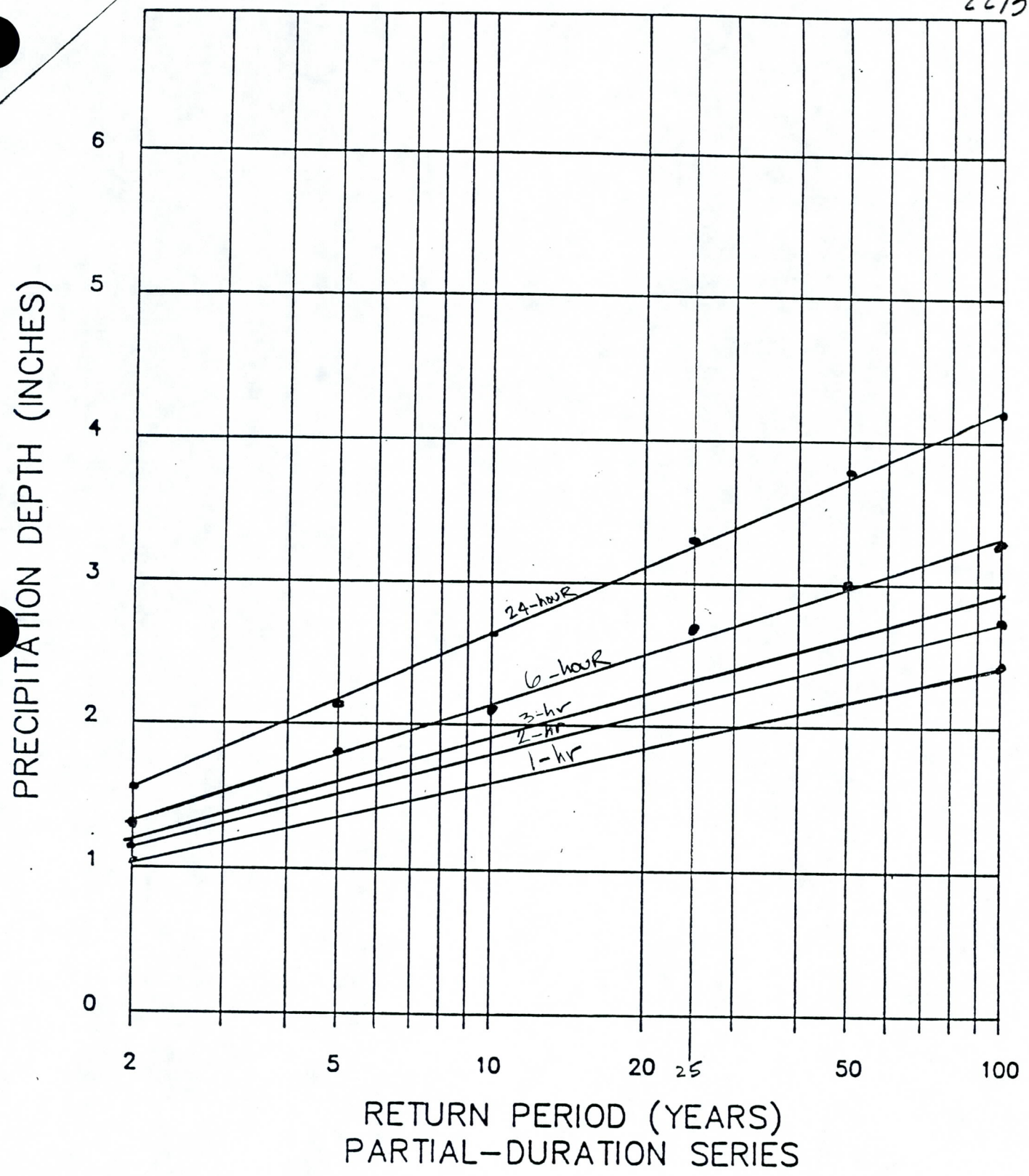


Figure 2.14
Precipitation Depth versus Return Period for Partial-Duration Series

VOLUME CALCULATIONS

$$V = C\left(\frac{P}{12}\right)A \qquad A = 2.626 \text{ ACRES}$$

$C_w = 0.56$

$\Rightarrow$ (EQ 3.4, HDMMC)

FOR 10 YR STORM: $P_{10\,YR}^{2\,HR} = 1.80$ INCHES

50 YR STORM: $P_{50}^{2} = 2.45$ INCHES

$$V_{10YR} = (.56)\left(\frac{1.8}{12}\right)(2.626) = .221 \text{ ACRE-FEET}$$

$$V_{50YR} = (.56)\left(\frac{2.45}{12}\right)(2.626) = .300 \text{ ACRE-FEET}$$

$$Q_{10} = CiA = (.56)(6.1)(2.626) = 8.97 \text{ cfs}$$

$$Q_{50} = CiA = (.56)(8.3)(2.626) = 12.206 \text{ cfs}$$

$T_{C\,(BOTH)} = 5$ MIN.

$T_r = 13.6$ (TABLE 3.2, PIMA CO S.W.D.R.M.).

FOLLOWING SPREAD SHEET CALCULATED FOLLOWING PIMA CO. STORMWATER DETENTION / RETENTION MANUAL

SPREAD SHEET SHOWS SYNTHETIC FLOOD HYDROGRAPH.

SYNTHETIC FLOOD HYDROGRAPH
FOR THE STEEP GRADE FACILITY
AND UNDERPASS PUMP STATIONS

UNIT HYDROGRAPH

t/Tr	q/Qp	v/V
0.0	0.000	0.000
0.1	0.025	0.002
0.2	0.087	0.007
0.3	0.160	0.020
0.4	0.243	0.036
0.5	0.346	0.063
0.6	0.451	0.096
0.7	0.576	0.136
0.8	0.738	0.180
0.9	0.887	0.253
1.0	1.000	0.325
1.1	0.924	0.400
1.2	0.839	0.464
1.3	0.756	0.523
1.4	0.678	0.578
1.5	0.604	0.627
1.6	0.545	0.671
1.7	0.482	0.707
1.8	0.424	0.742
1.9	0.372	0.773
2.0	0.323	0.799
2.2	0.241	0.841
2.4	0.179	0.875
2.6	0.136	0.900
2.8	0.102	0.917
3.0	0.078	0.932
3.4	0.049	0.953
3.8	0.030	0.965
4.2	0.020	0.973
4.6	0.012	0.979
5.0	0.008	0.983
7.0	0.000	1.000

SYNTHETIC FLOOD HYDROGRAPH FOR THE STEEP GRADE FACILITY

FOR 10 YEAR STORM:

V= 0.221 ACRE-FT
Q= 8.97 CFS
Tr= 13.600 MIN.

t MIN.	q CFS	Σ v (ACRE-FT)	Σ v (GALLONS)	PUMP RATE (GPM)	Σ VOLUME PUMPED (GALLONS)	STORAGE (GALLONS)	STANDING WATER (GALLONS)
0.00	0.000	0.000	0	0	0	0	0
1.36	0.224	0.000	144	0	0	144	0
2.72	0.780	0.002	504	0	0	504	0
4.08	1.435	0.004	1440	0	0	1440	0
5.44	2.180	0.008	2592	1300	1768	824	0
6.80	3.104	0.014	4537	1300	3536	1001	0
8.16	4.045	0.021	6913	1300	5304	1609	0
9.52	5.167	0.030	9793	1300	7072	2721	0
10.88	6.620	0.040	12961	2800	10880	2081	0
12.24	7.956	0.056	18218	2800	14688	3530	0
13.60	8.970	0.072	23403	2800	18496	4907	0
14.96	8.288	0.088	28803	2800	22304	6499	0
16.32	7.526	0.103	33412	2800	26112	7300	0
17.68	6.781	0.116	37660	2800	29920	7740	0
19.04	6.082	0.128	41621	2800	33728	7893	0
20.40	5.418	0.139	45149	2800	37536	7613	0
21.76	4.889	0.148	48317	2800	41344	6973	0
23.12	4.324	0.156	50910	2800	45152	5758	0
24.48	3.803	0.164	53430	2800	48960	4470	0
25.84	3.337	0.171	55662	2800	52768	2894	0
27.20	2.897	0.177	57535	2800	56576	959	0
29.92	2.162	0.186	60559	2800	60559	0	0
32.64	1.606	0.193	63007	1300	63007	0	0
35.36	1.220	0.199	64807	0	63007	1800	0
38.08	0.915	0.203	66031	1300	66031	0	0
40.80	0.700	0.206	67112	0	66031	1080	0
46.24	0.440	0.211	68624	1300	68624	0	0
51.68	0.269	0.213	69488	0	68624	864	0
57.12	0.179	0.215	70064	0	68624	1440	0
62.56	0.108	0.216	70496	0	68624	1872	0
68.00	0.072	0.217	70784	1300	70784	0	0
95.20	0.000	0.221	72008	1300	72008	0	0

SYNTHETIC FLOOD HYDROGRAPH
FOR THE STEEP GRADE FACILITY

FOR 50 YEAR STORM:

V= 0.300 ACRE-FEET
Q= 12.21 CFS
Tr= 13.600 MIN.

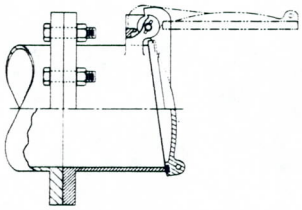
t MIN.	q CFS	Σ v (ACRE-FT)	Σ v (GALLONS)	PUMP RATE (GPM)	Σ VOLUME PUMPED (GALLONS)	STORAGE (GALLONS)	STANDING WATER (GALLONS)
0.00	0.000	0.000	0	0	0	0	0
1.36	0.305	0.001	195	0	0	195	0
2.72	1.062	0.002	684	0	0	684	0
4.08	1.953	0.006	1955	1300	1768	187	0
5.44	2.966	0.011	3519	1300	3519	0	0
6.80	4.223	0.019	6158	1300	5287	871	0
8.16	5.505	0.029	9384	1300	7055	2329	0
9.52	7.031	0.041	13294	2800	10863	2431	0
10.88	9.008	0.054	17595	2800	14671	2924	0
12.24	10.827	0.076	24730	2800	18479	6251	0
13.60	12.206	0.098	31768	2800	22287	9481	81
14.96	11.278	0.120	39099	2800	26095	13005	3605
16.32	10.241	0.139	45355	2800	29903	15452	6052
17.68	9.228	0.157	51123	2800	33711	17412	8012
19.04	8.276	0.173	56499	2800	37519	18980	9580
20.40	7.372	0.188	61288	2800	41327	19961	10561
21.76	6.652	0.201	65589	2800	45135	20454	11054
23.12	5.883	0.212	69108	2800	48943	20165	10765
24.48	5.175	0.223	72529	2800	52751	19779	10379
25.84	4.541	0.232	75560	2800	56559	19001	9601
27.20	3.943	0.240	78101	2800	60367	17734	8334
29.92	2.942	0.252	82207	2800	67983	14224	4824
32.64	2.185	0.263	85530	2800	75599	9931	531
35.36	1.660	0.270	87974	2800	83215	4759	0
38.08	1.245	0.275	89636	2800	89636	0	0
40.80	0.952	0.280	91102	1300	91102	0	0
46.24	0.598	0.286	93154	1300	93154	0	0
51.68	0.366	0.290	94327	0	93154	1173	0
57.12	0.244	0.292	95109	1300	95109	0	0
62.56	0.146	0.294	95696	0	95109	586	0
68.00	0.098	0.295	96087	0	95109	977	0
95.20	0.000	0.300	97749	1300	97749	0	0

CAST IRON

Flap Valves

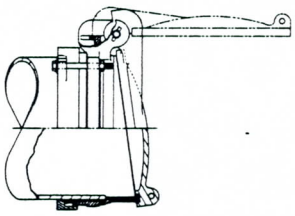
FOR PUMP DISCHARGE

Waterman Model PF-25 flap valves are designed for use on pump discharge lines and other pipe end closures to prevent entrance of back water. These valves are furnished with a variety of frame styles to fit most installation needs. A 7½° inclined seating plane is used to ensure that the valve will not "hang open" from slight pipe sagging or off grade. A positive stop prevents over opening.



The flange model (PF-25f) may be furnished with either iron or bronze seat faces. Bronze hinge pins are standard. Drilling is ANSI 125 lb. standard.

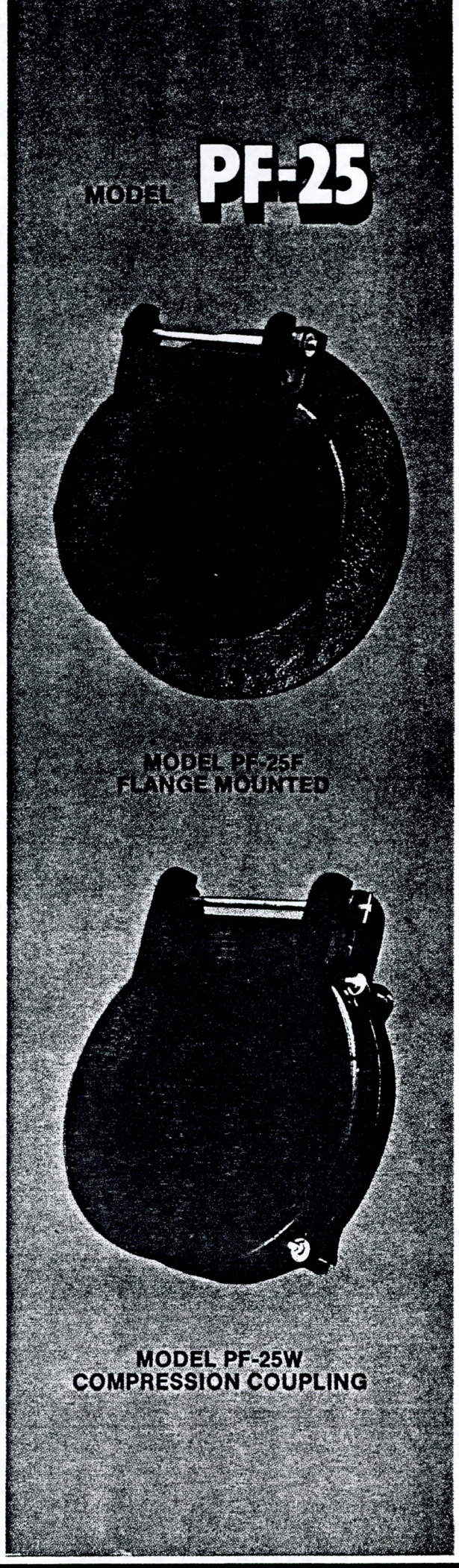
Cast Iron Body • Flange or Compression Mounted
Cast Iron Cover • Aluminum Cover Optional
Cast Iron, Bronze or Resilient Seat Faces
Bronze Hinge Pins • 7½° Seating Plane



The popular compression model (PF-25w) uses time proven wedge type seals to install quickly and easily on plain end standard steel pipe. A special gasket is furnished for use with O.D. sized steel pipe. This model is standard with a cast iron frame with machined seat face and a cast iron cover with a resilient neoprene rubber seat face. Follow ring is cast iron with rubber wedge gasket and plated steel draw bolts.

Valves are available with aluminum covers and neoprene seat faces where extra sensitivity is desired. Special treated bodies and collars for installation in concrete pipe are available.

See price list for sizes and weights available.



Waterman INDUSTRIES, INC.

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MEMPHIS, TN • GRAND ISLAND, NB • INDIANAPOLIS, IN

RED TOP WATER CONTROL GATES, VALVES and EQUIPMENT

BULLETIN 14.3(982) — PRINTED IN USA

Typical Specifications
F-25 & F-20 Moderate Duty Drainage Flap Gates

General

The flap gate shall be designed to allow free outflow and prevent backflow for maximum seating heads up to 25 (20) feet. Gates shall be Waterman Model F-25 (or F-20 for square/rectangular) or equal.

Construction

The frame shall be cast iron of flatback or spigotback design, with machined seating surface inclined from vertical at a minimum of 2½° to assure positive closure. For flatback gates mounted to thimbles, the gate flange shall be machined and drilled to match thimble.

The cover shall be cast iron, cast in one piece, with reinforcing ribs or domed construction, designed to withstand the seating head specified. An integral cast on lifting eye shall be provided.

Seating surfaces for frame and cover shall be:

a) machined iron
or
b) bronze seats securely mounted and attached to frame and cover.
or
c) a bronze seat securely mounted and attached to frame with neoprene seat bonded into dovetail groove in cover to cushion cover on closing.

All machined seats shall have a minimum 63 microinch finish.

The gate shall be provided with an adjustable, double pivoted hinge linkage so designed to permit complete seating, full opening, and with stops or other arrangement to prevent the cover from rotating sufficiently to become wedged in the open position. Pivot lugs mounted to frame shall be adjustable to allow adjustment of hinge links without having to remove cover from gate. The hinge links shall be bronze bushed, structural steel (high strength malleable iron, cast manganese bronze, or wrought stainless steel).

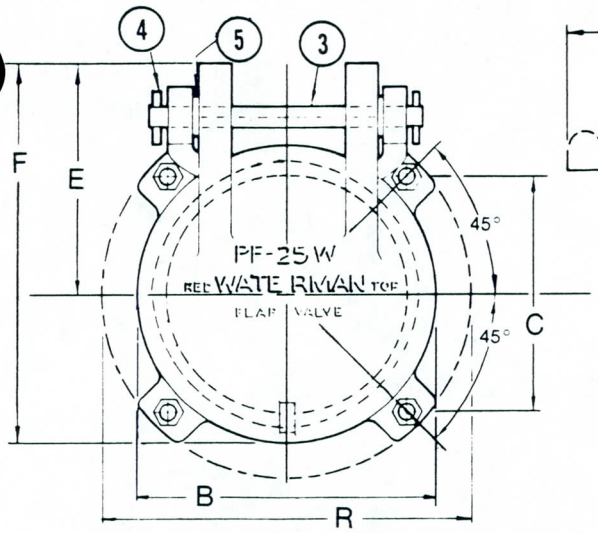
All assembly hardware shall be type 18-8 stainless steel.

Finish

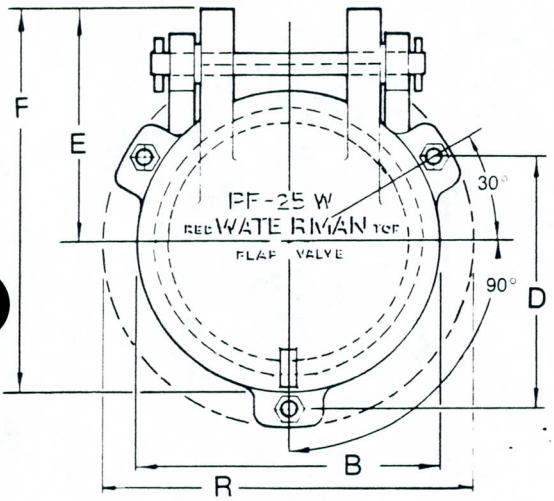
All cast iron shall be painted with manufacturer's standard shopcoat paint (special paint). Structural steel hinge arms shall be galvanized. All bronze and stainless steel parts do not require further finish.

Materials

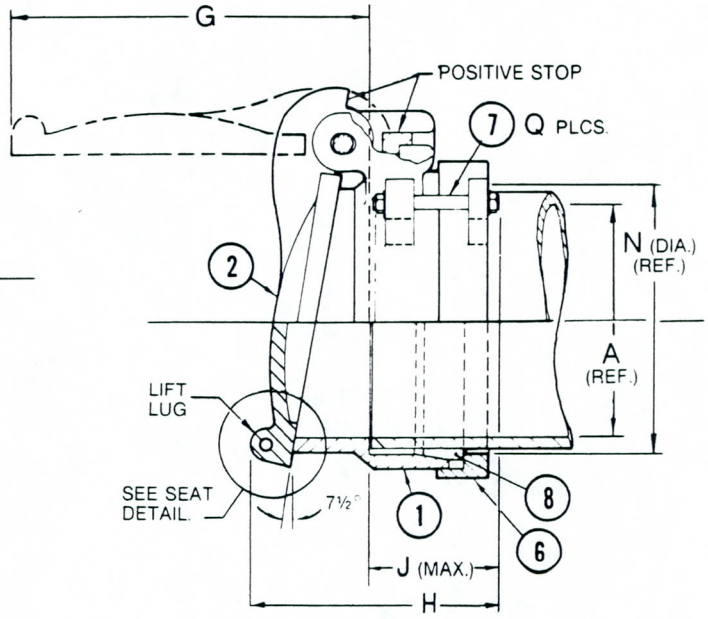
Frame and Cover - Cast Iron per ASTM A-126, Class B.
Pivot Lug - Ductile Iron per ASTM A-536, Gr. 65-45-12.
Hinge Link - Structural Steel per ASTM A-36, galvanized per ASTM A-123.
Bronze Bushings and Washers - Commercial Bronze.
Assembly Hardware and Pins - 18-8 Stainless Steel (Type 304).



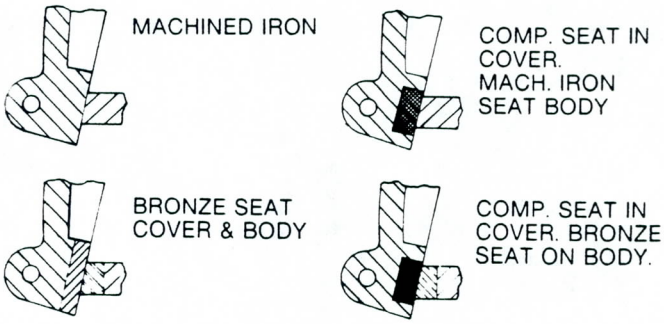
SIZES 6-14 ONLY



SIZES 4 & 5 ONLY



ALTERNATE SEATS AVAILABLE



GATE DIMENSIONS IN INCHES

GATE SIZE	4	5	6	8	10	12	14
A							
B	5⅝	6¾	8	9⅞	12½	14½	16
C	—	—	6	7½	9⅛	10½	12
D	4½	5½	—	—	—	—	—
E	5¼	5½	6	7½	8¼	9½	10½
F	9	9½	10	12¼	14¼	17	18½
G	7	8⅜	9¾	11¾	14	16½	18¼
H	5¼	5¼	6¼	6¼	6½	7	7½
J	2	2¼	2⅝	2⅝	2⅝	2⅝	2⅝
N	4⅝	5⅝	6¾	8¾	10⅞	12⅞	14⅛
Q	3	3	4	4	4	4	4
R	6½	8	9⅜	11¾	13⅞	15⅞	17⅝

PARTS LIST

1. BODY (STD.)
2. COVER
3. HINGE PIN
4. SPRING PIN
5. WASHER
6. FOLLOW RING
7. RING BOLT, NUT & WASHER
8. PIPE SEAL GASKET

NOTES

1. DESIGNED FOR USE ON PUMP DISCHARGE LINES.

MODEL		
PF-25W FLAP VALVE		
SCALE	CATALOG DWG. NO.	REVISION NO.
NONE	**0013-2**	**1**

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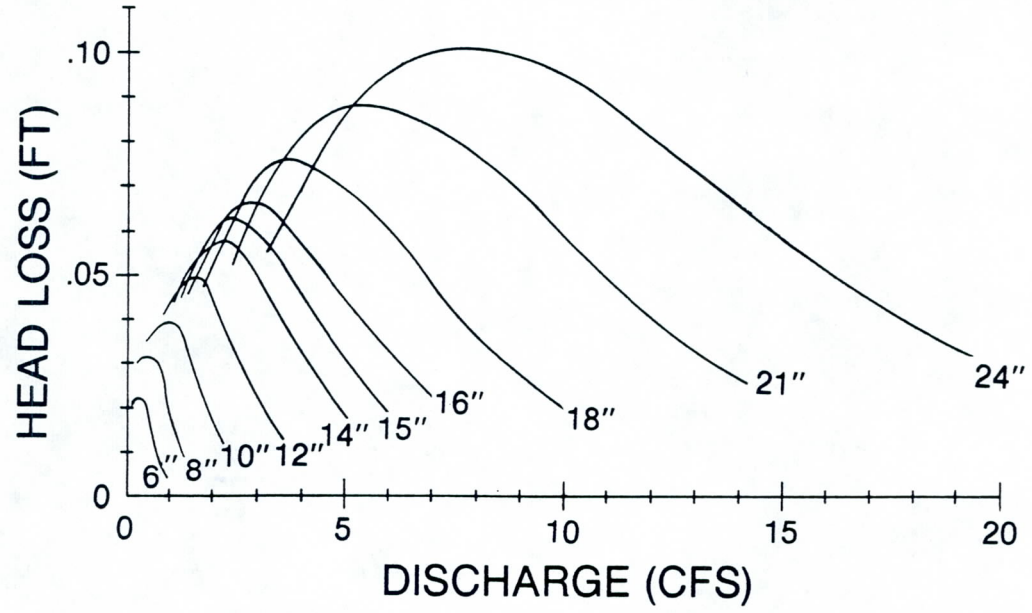
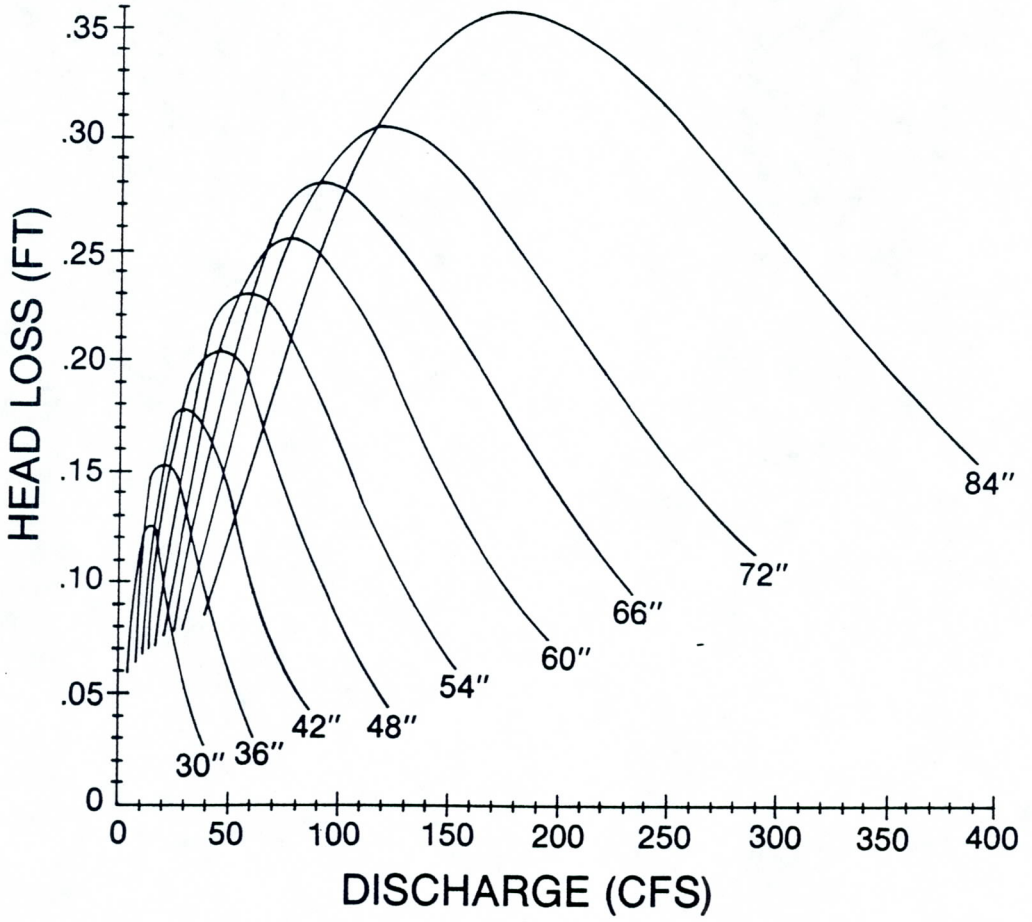
RED TOP WATER CONTROL GATES, VALVES and EQUIPMENT

NOTE: FOR PRELIMINARY DESIGN PURPOSES ONLY
DO NOT USE FOR INSTALLATION
UNLESS PART OF CERTIFIED & APPROVED SUBMITTAL

PERFORMANCE CHART APPLICABLE FOR WATERMAN F-10 & F-50 GATES. HEAD LOSS THRU HEAVIER F-25 & F-55 SERIES GATES MAY BE SLIGHTLY GREATER.





MODEL	AUTOMATIC DRAINAGE (FLAP) GATE PERFORMANCE CHART	
SCALE	CATALOG DWG. NO. 0049	REVISION NO.

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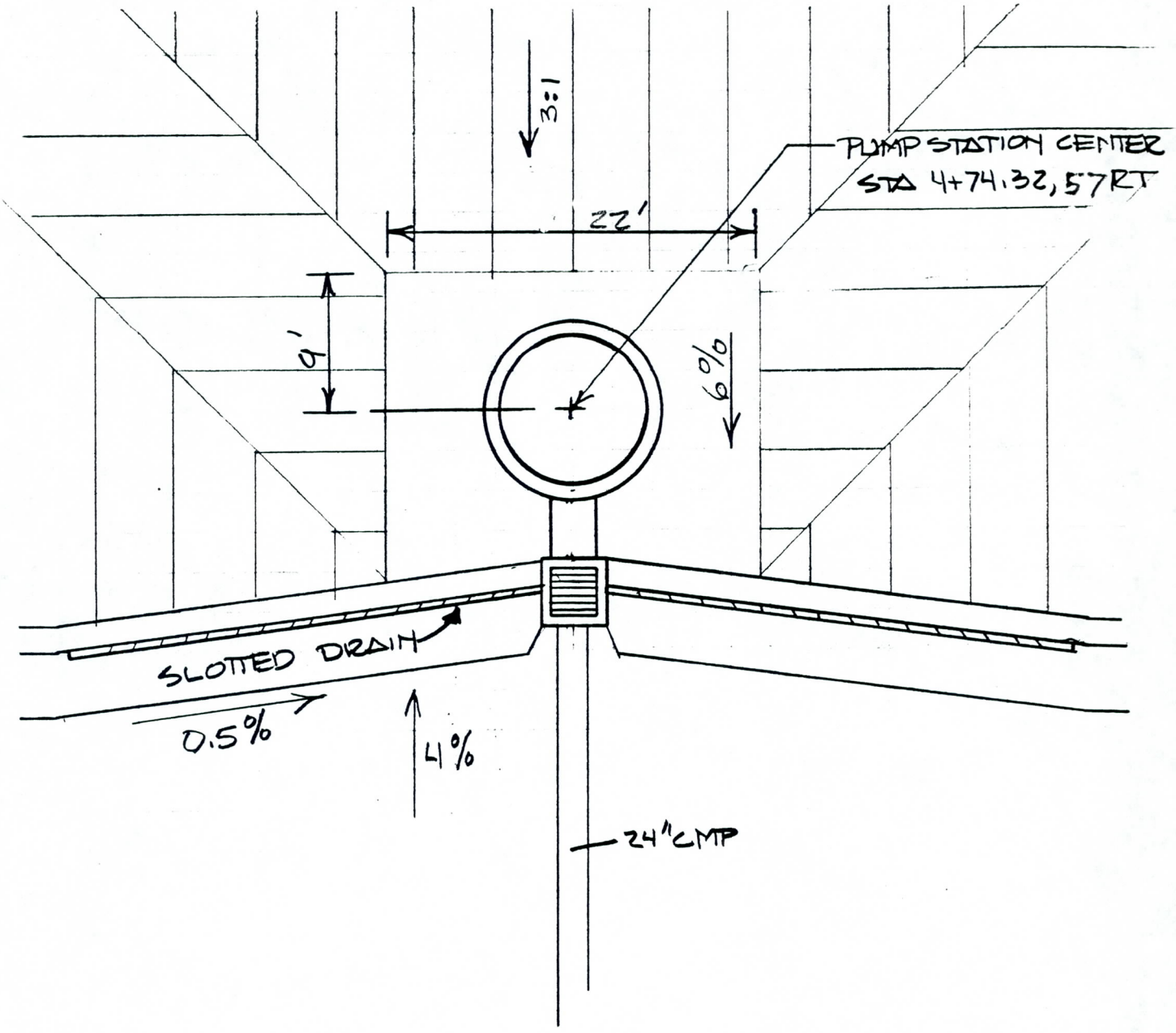
SVERDRUP

JOB Toyota 40477 SHEET NO. 31 OF 31

DATE 7/91

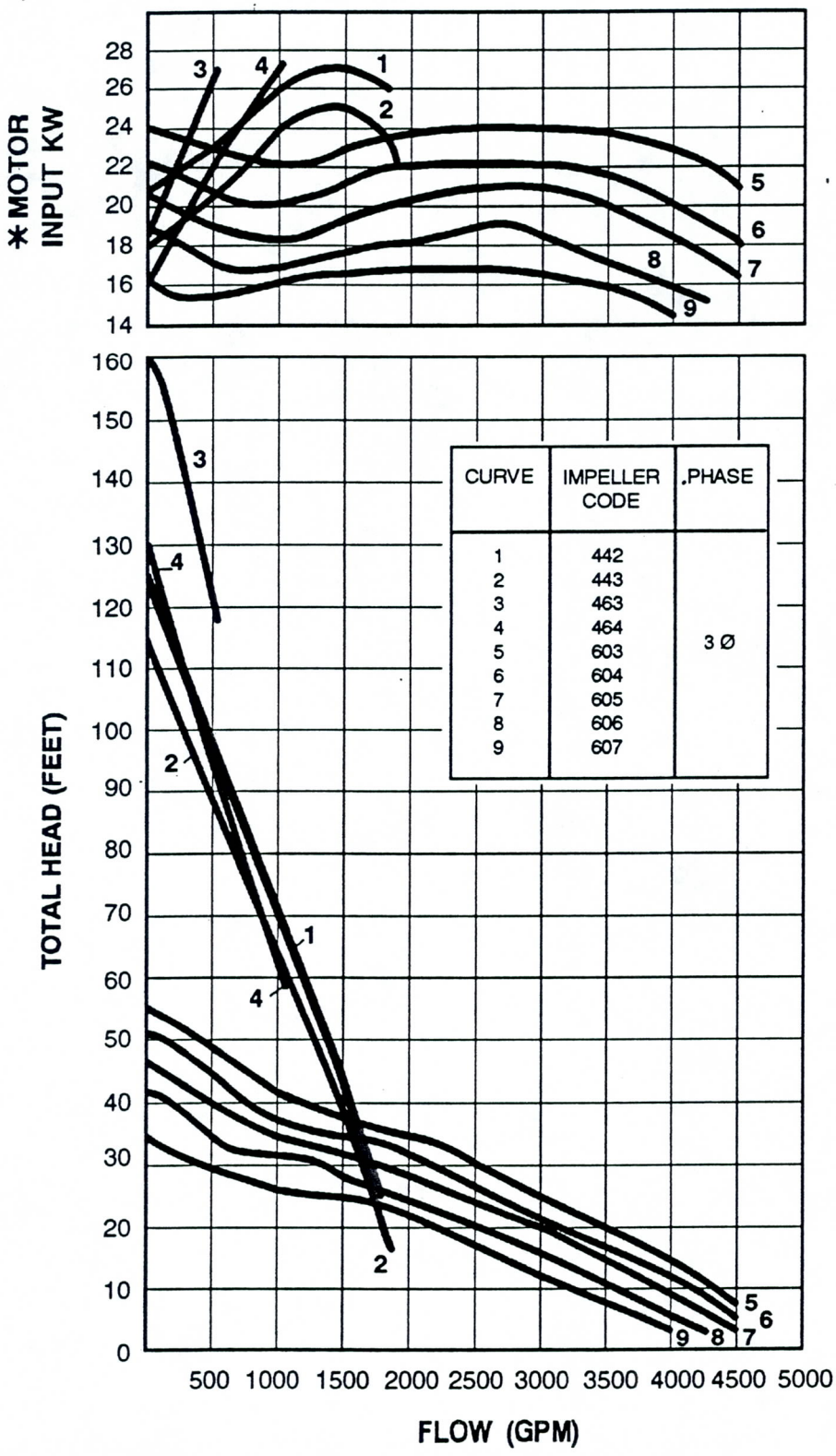
COMPUTATIONS FOR Steep Grade BY BSW CHKD RJT



C-3170

SECTION	MODEL
3	3170
SUPERSEDES	ISSUED
	6/90

FAMILY OF PERFORMANCE CURVES

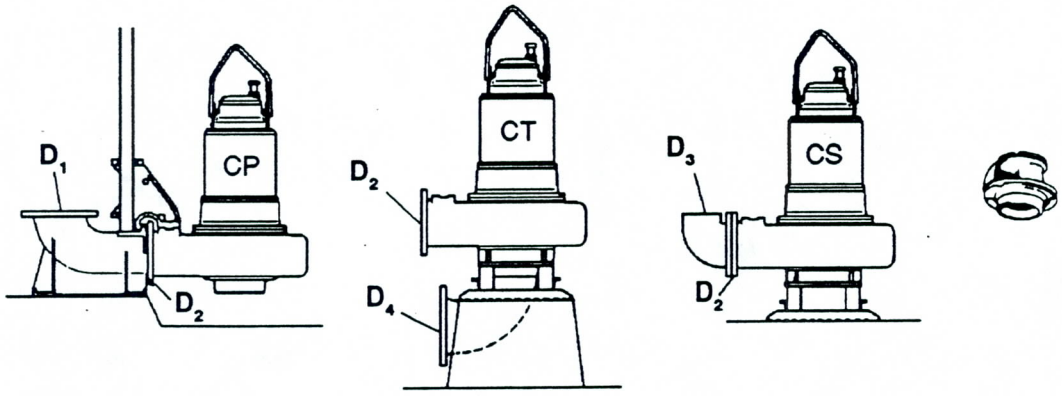


NOTE:
FAMILY OF PERFORMANCE CURVES ARE FOR PRE-SELECTION ONLY.
SEE INDIVIDUAL CURVES IN THIS SECTION FOR FINAL SELECTION.

SECTION	MODEL	C-3170
3	3170	
SUPERSEDES	ISSUED 6/90	IMPELLER/MOTOR - NOM. SIZES

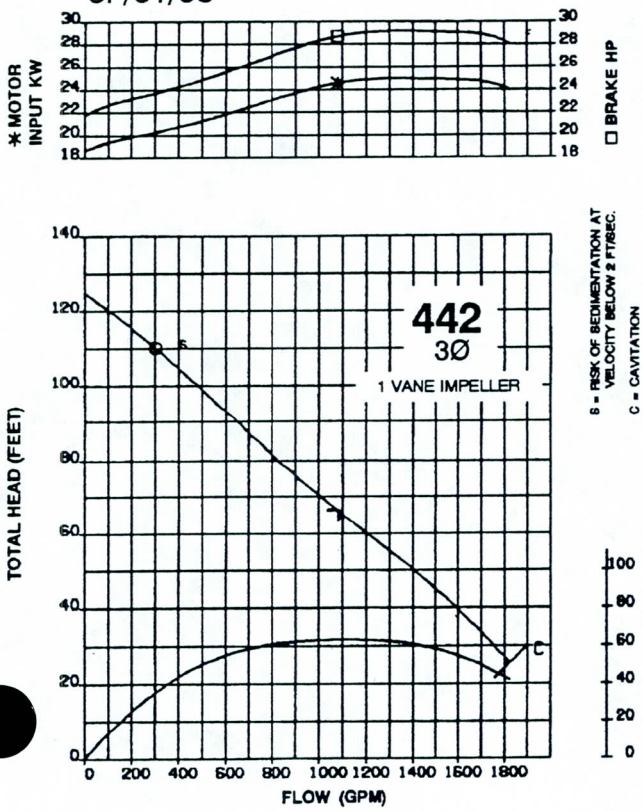
PUMP MODEL	IMPELLER CODE	HP RATING			VAC	RPM	D1	D2	D3	D4
		CP	CT	CS						
3170 3Ø	463 464	30	30	30	200 230/460 575	1740	4" or 6"	4"	4"	6" or 8"
	442 443	30	30	30			6" or 8"	6"	6" or 8"	8"
	603 * 604 605 606 607 #	25	25	25		1170	10" or 12"	10"	8" or 10"	12"

* NOT AVAILABLE FOR WARM LIQUID APPLICATIONS.
\# ALSO AVAILABLE FOR 194° F WARM LIQUID APPLICATIONS.
ALL OTHER CONFIGURATIONS AVAILABLE FOR 158° F WARM LIQUID APPLICATIONS.

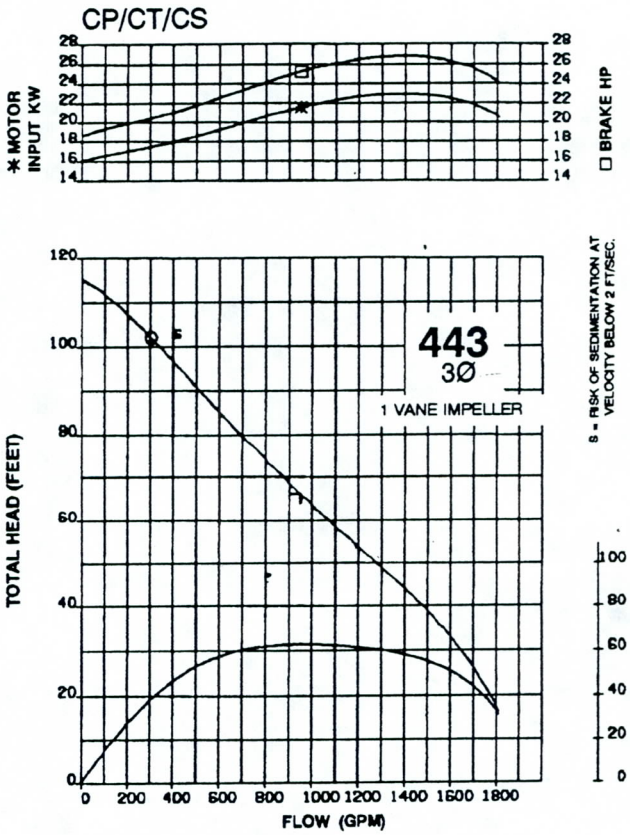


SECTION	PAGE	WASTEWATER	IMPELLER PERFORMANCE CURVES	C-3170
3	1			
SUPERSEDES	ISSUED 6/90			

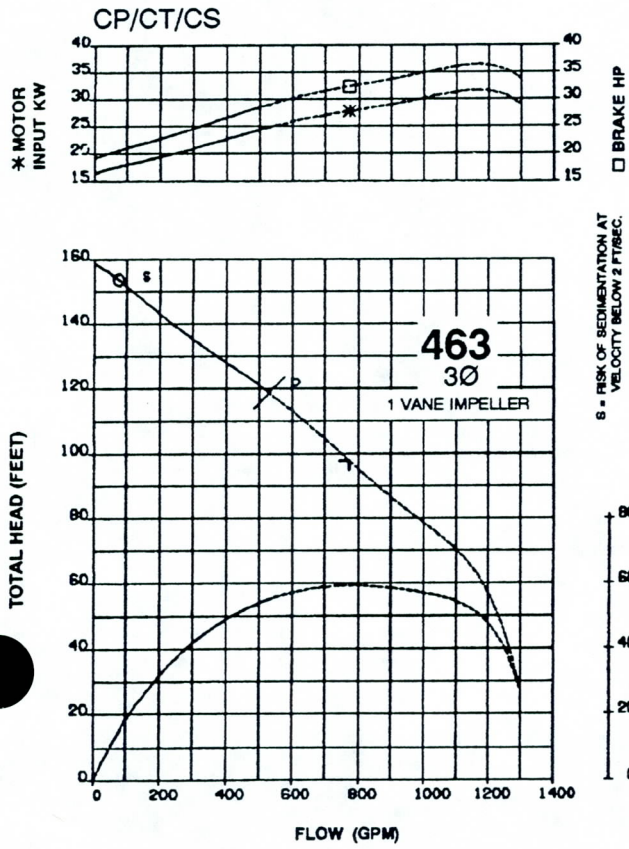
CP/CT/CS



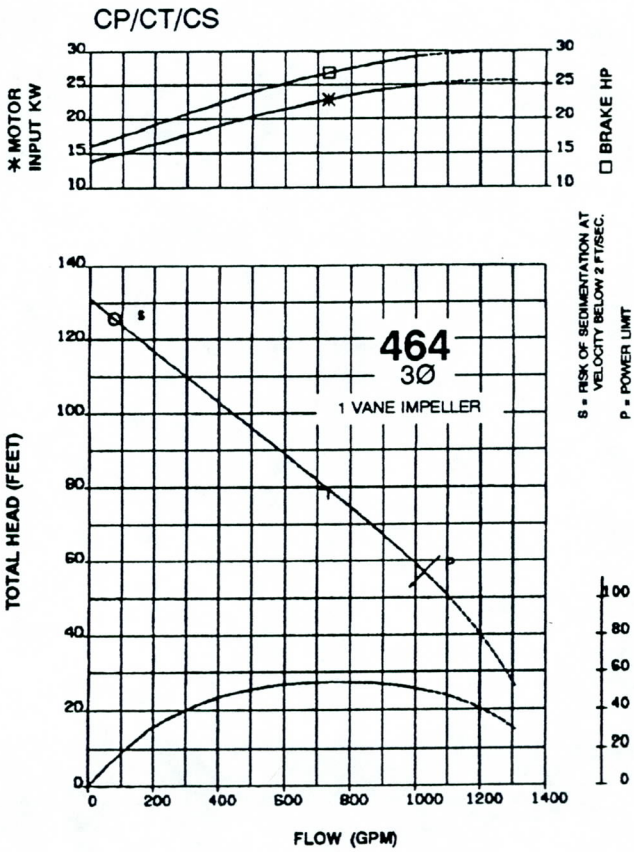
CP/CT/CS



CP/CT/CS



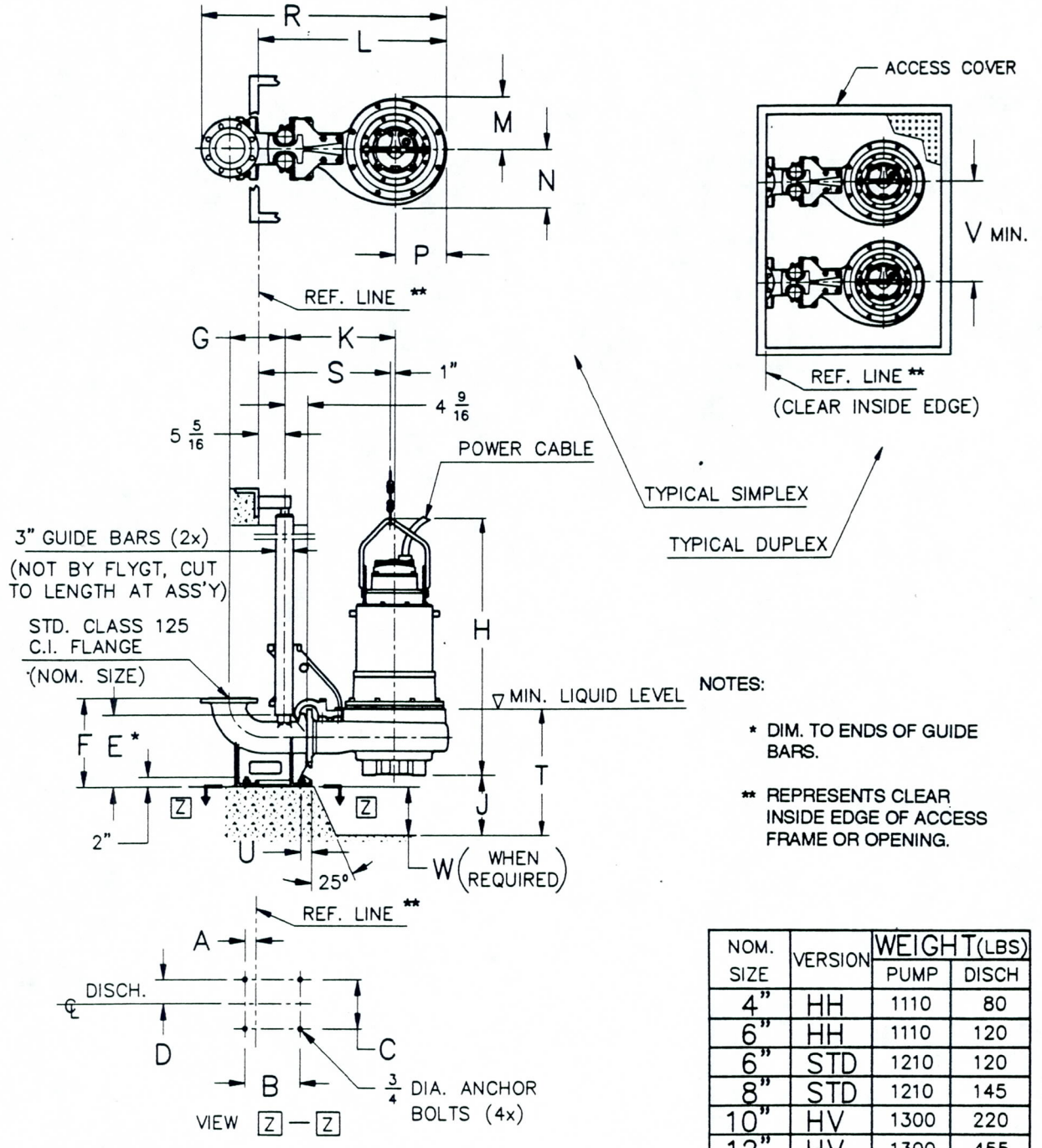
CP/CT/CS



CP-3170

Outline Dimensions

SECTION	MODEL
4	3170
SUPERSEDES	ISSUED 6/90



NOTES:

* DIM. TO ENDS OF GUIDE BARS.

** REPRESENTS CLEAR INSIDE EDGE OF ACCESS FRAME OR OPENING.

NOM. SIZE	VERSION	WEIGHT (LBS) PUMP	DISCH
4"	HH	1110	80
6"	HH	1110	120
6"	STD	1210	120
8"	STD	1210	145
10"	HV	1300	220
12"	HV	1300	455

ALL DIMENSIONS IN INCHES

NOM. SIZE	VERSION	DIMENSIONAL CHART A	B	C	D	E	F	G	H	J	K	L	M	N	P	R	S	T	U	V	W
4"	HH	3/4	9 7/8	8	4	10 1/4	15 3/4	9 3/4	50 3/8	4 3/8	22 1/4	38	10	11 1/4	10 3/8	46 7/8	26 5/8	17	2 3/4	29 1/2	4
6"	HH	2 3/8	11	9 1/2	4 3/4	13 1/4	17 3/4	11	50 3/8	4 1/2	22 1/4	38	10	11 1/4	10 3/8	49 3/4	26 5/8	17	2 1/4	29 1/2	2
6"	STD	2 3/8	11	9 1/2	4 3/4	13 1/4	17 3/4	11	51 3/8	4 1/4	22 1/4	38	10	11 1/4	10 3/8	49 1/2	26 5/8	18	2 1/4	29 1/2	1 3/4
8"	STD	3 1/2	11	9 1/2	4 3/4	13 3/4	17 3/4	12 1/8	51 3/8	4	22 1/4	38	10	11 1/4	10 3/8	51 3/4	26 5/8	17	2 1/4	29 1/2	1 1/4
10"	HV	12 1/8	19 11/16	9 1/2	4 3/4	14 1/2	17 3/4	14 1/8	53 1/4	6 1/2	24 1/4	43 3/8	11 5/8	16 1/8	13 3/4	60 1/4	28 5/8	22	2 1/4	35 1/2	6
12"	HV	7 5/8	19 11/16	20 1/2	10 1/4	25 1/4	31 1/2	17 1/16	53 1/4	11 3/8	24 1/4	43 3/8	11 5/8	16 1/8	13 3/4	64 3/4	28 5/8	27	3	35 1/2	0

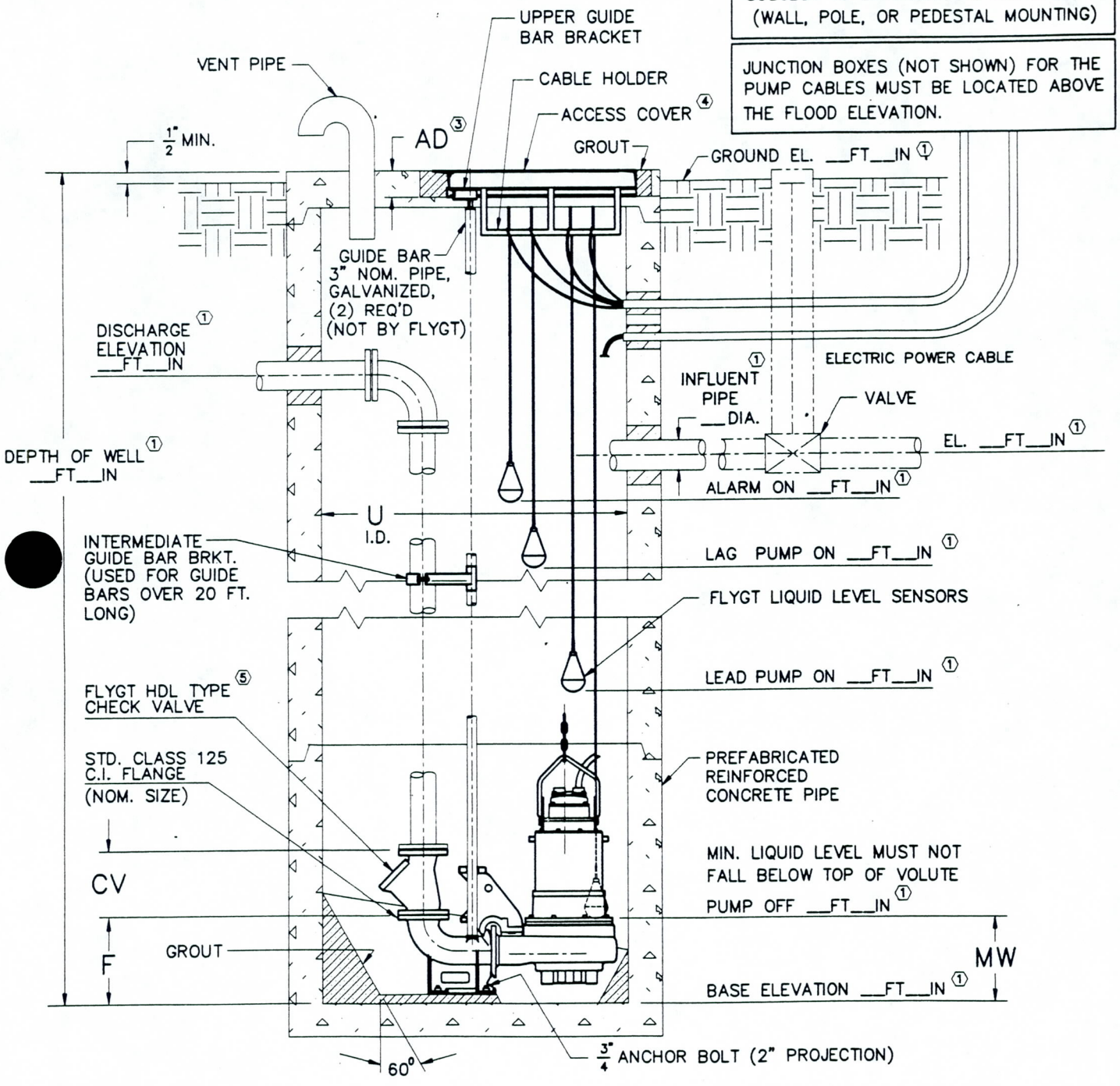
SECTION	MODEL
5	3170
SUPERSEDES	ISSUED 6/90

CP-3170

Lift Station Dimensions

FLYGT CONTROL CENTER
SUBJECT TO ENGINEER'S SPECIFICATIONS
(WALL, POLE, OR PEDESTAL MOUNTING)

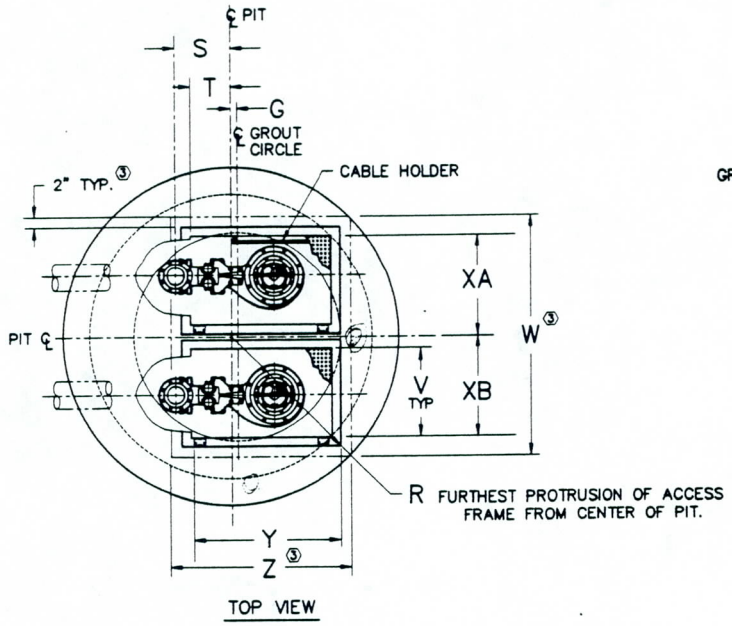
JUNCTION BOXES (NOT SHOWN) FOR THE PUMP CABLES MUST BE LOCATED ABOVE THE FLOOD ELEVATION.



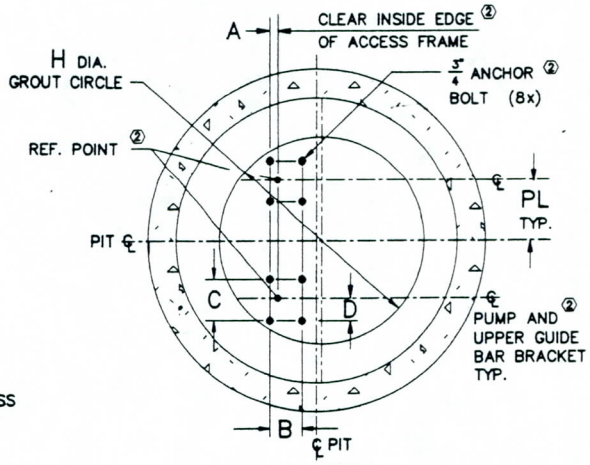
NOTES:

1. INDICATES INFORMATION TO BE DETERMINED BY OTHERS.
2. LOCATE ANCHOR BOLTS USING CLEAR INSIDE EDGE OF ACCESS FRAME AND CENTER LINE OF PUMP AS REF. POINT.
3. GROUT OPENING FOR ACCESS FRAME
4. HEAVY DUTY ACCESS COVER AVAILABLE FROM FLYGT. (FOR DIM. CONSULT ENGR.)
5. CONFIGURATION AND DIMS. SHOWN ARE MIN. REQUIREMENTS ONLY. ALL DETAILS, INCLUDING SIZING OF PIT, TYPE, LOCATION AND ARRANGEMENT OF VALVES AND PIPING, ETC. ARE TO BE SPECIFIED BY THE CONSULTING ENGINEER AND ARE SUBJECT TO HIS APPROVAL.

SECTION	MODEL
5	3170
SUPERSEDES	ISSUED 6/90



TOP VIEW



BASE SECTION

Duplex

ALL DIMENSIONS IN INCHES

DIMENSIONAL CHART

NOM. SIZE	VERSION	STATION														COVER							
		A	B	C	D	F	G	H	R	S	T	U	CV	MW	PL	SIZE	V	W	XA	XB	Y	Z	AD
4"	HH	¾	9 7/8	8	4	15 ¾	1	66	53	19 ¼	14 ¾	96	11 ½	17	19	(2)C	30	78	33 ⅜	34 ⅝	48	58	4 ⅝
6"	STD	2 ⅜	11	9 ½	4 ¾	17 ¾	2	68	54	19	13 ⅜	96	14	17	19	(2)C	30	78	33 ⅜	34 ⅝	48	58	4 ⅝
6"	HH	2 ⅜	11	9 ½	4 ¾	17 ¾	2	68	55	16 ⅝	11	96	14	18	19	(2)C	30	78	33 ⅜	34 ⅝	48	58	4 ⅝
8"	STD	3 ½	11	9 ½	4 ¾	17 ¾	2	68	55	18	11 ⅛	96	19 ½	17	19	(2)C	30	78	33 ⅜	34 ⅝	48	58	4 ⅝
10"	HV	12 ⅛	19 11/16	9 ½	4 ¾	17 ¾	1	84	60	24	15 ⅛	120	39 ⅜	22	23 ¼	(2)F	36	48 ½	39	43 ½	48	60 ½	5 ⅛
12"	HV	7 ⅝	19 11/16	20 ½	10 ¼	31 ½	1	90	61	23 ¾	12	120	47 ¼	27	23 ¼	(2)F	36	48 ½	39	43 ½	48	60 ½	5 ⅛

Flygt Access Covers

Cover Model	A	B	C	F	+D	H	G	+E
Nominal Size	24" x 24"	30" x 30"	30" x 48"	36" x 48"	42" x 42"	42" x 48"	48" x 54"	48" x 72"

Pump Model	Cover Models	
	Simplex	Duplex
3067 - 2"	A	B
3067 - 2.5"	A	C
3080 - 3",4"	B	C
3085 - 3",4"	B	C
3085/82 - 3",4"	B	C
3102 - 4",6",8"	B	C
3127 - 4"	B	C
3127 - 6",8" Std.	B	C
3127 - 8" HV	+D	F
3152 - 4",6",8" Std.	+D	F
3152 - 10" HV	C	E
3152 - 12" HV	C	E
3170 - 4",6",8"	C	**C
[redacted]70 - 10",12" HV	F	**F
[redacted]01 - 6",8" HH	+D	**C
3201 - 8",10" Std.	F	**F
3201 - 12" HV	G	**G
3201 - 14" HV	G	**G
3230 - 8"	G	**G
3300 - 8" HH	C	**C
3300 - 12",14"	G	**G
3305 - 12"	E	**E
3311 - 12",14"	E	**E
3355 - 14"	E	**E

Optional Cover Material:

Steel (Standard)

Steel (Heavy Duty)

Aluminum (With Steel Hardware)

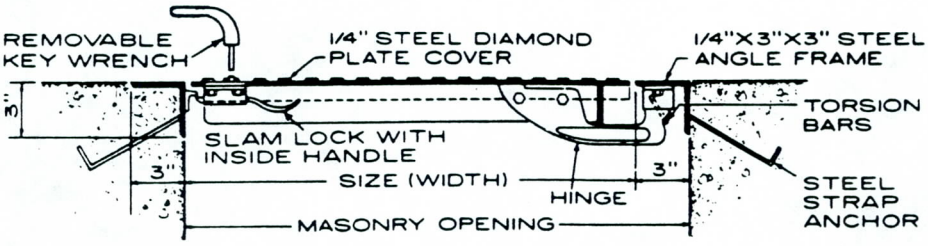
Cast Iron (Heavy Duty) Contact Flygt

** Requires 2 Covers
+ Double Door Cover

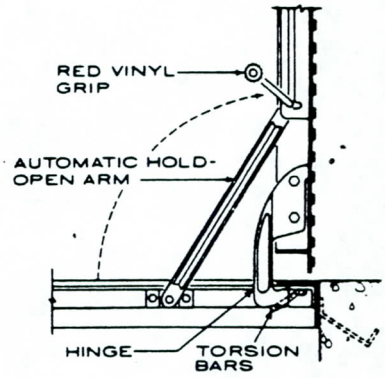
Standard Steel Access Covers

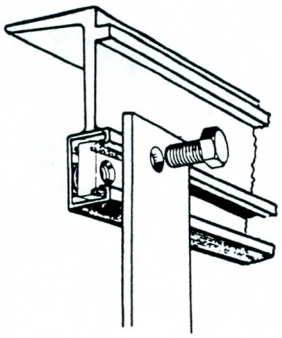
Typical Cover Sectional Views

SECTION	PAGE
10	3
SUPERSEDES	ISSUED 4/86

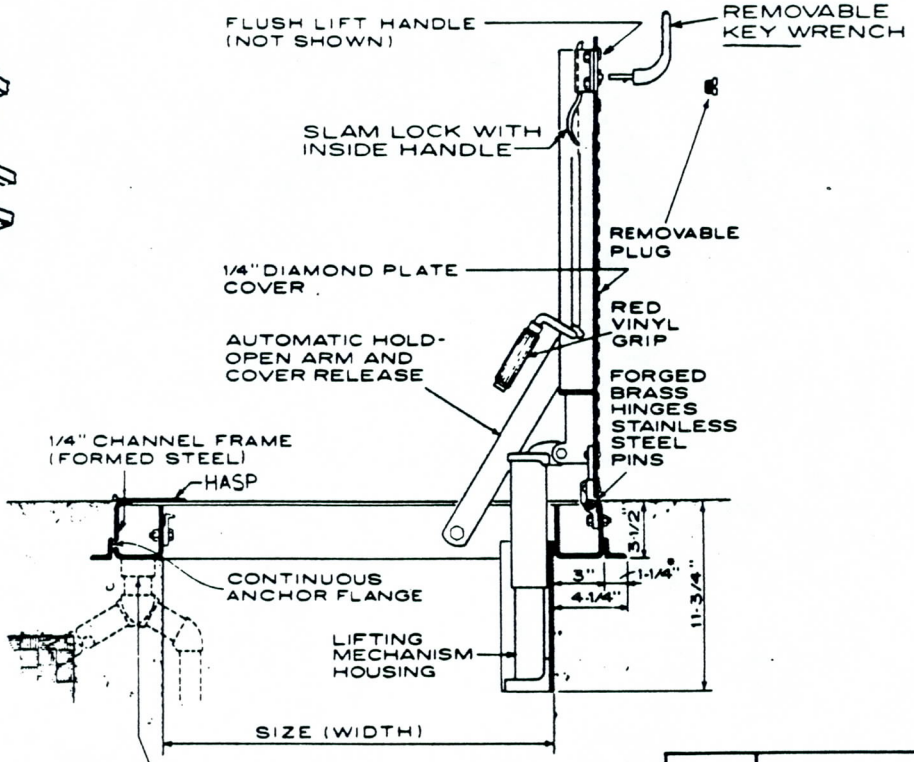


MODELS "A","B","C","D" *





UNISTRUT FEATURE INCORPORATED IN ALL FLYGT COVERS



MODELS "E"*,"F","G"

SIZE	LIVE LOAD CAPACITY
A-D	150 lbs. per square ft.
E-G	300 lbs. per square ft.
A-G HD-HEAVY DUTY	*H-20

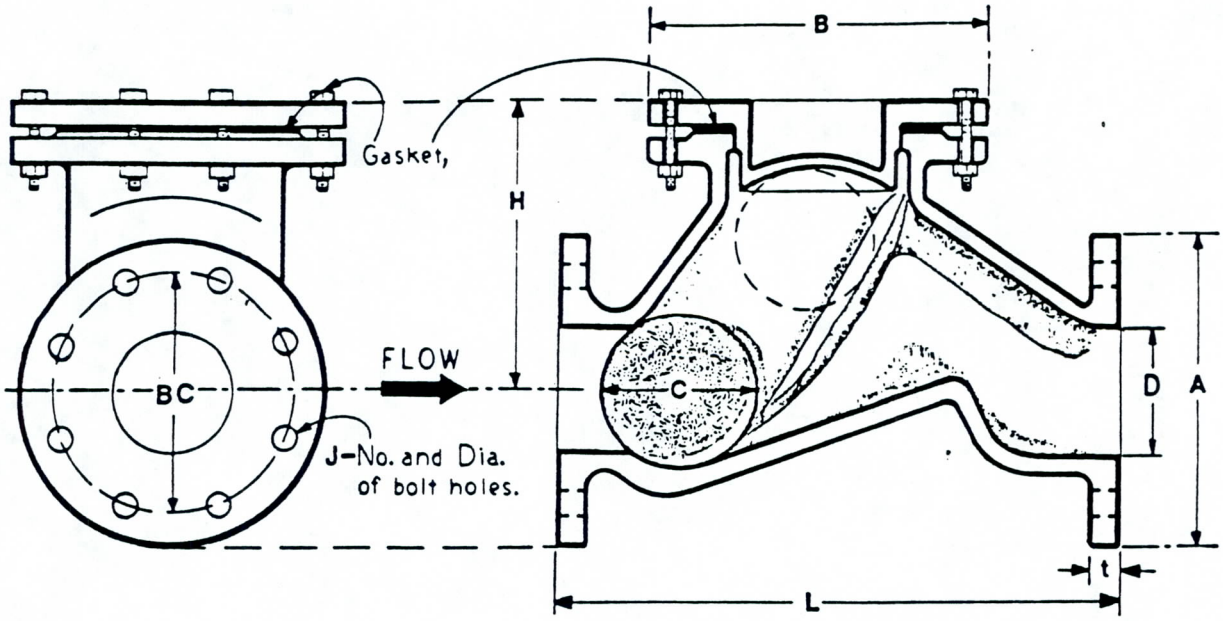
* H-20: One wheel load capacity 16,000 lbs. on area 14" x 16" (truck tire print). Recommended in parking areas, driveways, etc. NOT recommended for fast moving highway traffic.

* DOUBLE LEAF

SECTION	PAGE
10	20
SUPERSEDES	ISSUED
	4/86

Flygt HDL Ball Check Valves

Type 2016



Dimensions in inches

SIZE	D O.D. FLG	A* O.D. CVR	B BALL DIA.	C C.L. TO COVER	H LENGTH	L* FLG. THK	T** BOLT CIR.	BC NO.	J BOLT HLE. DIA.	WT LBS.
2"	6-1/2	6-7/8	2-1/2	5-3/8	9-1/4	5/8	4-3/4	4	3/4	31
2-1/2"	7-1/8	7-3/4	3-1/4	6-5/16	11-5/8	11/16	5-1/2	4	3/4	46
3"	7-7/8	8-1/2	4	7-1/8	13-1/2	3/4	6	4	3/4	57
4"	9	10-1/4	5	8-7/8	17-1/2	15/16	7-1/2	8	3/4	97
5"	10	11-7/8	6	10-5/8	20-1/2	15/16	8-1/2	8	7/8	137
6"	11-1/4	13-3/8	7-1/2	12-1/4	24	1	9-1/2	8	7/8	209
8"	13-1/2	16-3/8	10	15	31-5/8	1-1/8	11-3/4	8	7/8	365
10"	16	19-7/8	12-5/8	19	39-1/2	1-3/16	14-1/4	12	1	624
12"	19	22-1/2	14-5/8	22	47-1/4	1-1/4	17	12	1	832
14"	21	26	17-3/8	25-3/4	55-1/8	1-3/8	18-3/4	12	1-1/8	1400
16"	23-1/2	28-3/4	19-5/8	29-1/4	63	1-1/2	21-1/4	16	1-1/4	----
18"	25	31-7/8	22	33	70-7/8	1-1/2	22-3/4	16	1-1/4	----
20"	27-1/2	35-1/4	24-1/2	36-1/2	78-3/4	1-5/8	25	20	1-1/4	----

**TOLERANCE ± 1/16" *TOLERENCE ± 1/8"

Note: When static head on check valve is less than 10' of water or 4 PSI., valve should be installed in the vertical position only.

BODY: Cast Iron: ASTM A159-72 Class 35

FLANGE DRILLING: ANSI B16.1 Class 125 Flat Faced Bolt Holes straddle center-line.

BALL: Hollow steel with vulcanized Nitrile Rubber Covering.

SINKING TYPE: SP. GR. Greater than 1.0

FLOATING TYPE: SP. GR. Less than 1.0

WORKING PRESSURE: 150 P.S.I.G. max.

WORKING TEMPERATURE: 185°F. max.

SERVICE: Generally used for sewage. For other flowing media, various types of coatings and ball elastomers are available. Details are required for proper evaluation.

Valves for higher working pressures available using ANSI Class 250 Flanges, Ductile Iron construction

Mix-Flush Valve

SECTION	PAGE
10	15
SUPERSEDES	ISSUED
	4/86

The motorized (24V AC) Mixing Valve is primarily intended to be attached to the C-Pump volute for the purposes of "stirring up" or mixing the sediment at the bottom of the lift station.

During periods of low inflow, large amounts of sludge, rags, sand etc. will settle at the bottom of the station. The biological sludge usually remains stable and tends to form sludge banks that remain stable even at high inflow rates.

Cavities are formed near the inlet to the pumps causing some hydraulic problems. Also ,the sludge consumes the free oxygen brought in by the water causing corrosion along with the more serious problem of forming very poisonous hydrogen sulfide.

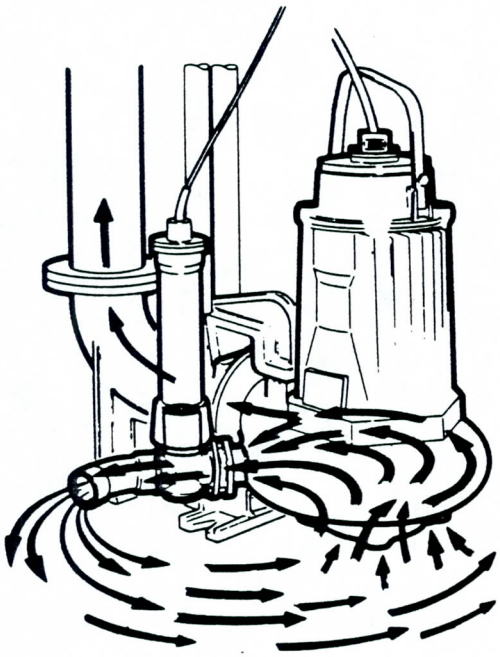
The opening and closing of the mixing valve is monitored via the pump control and can be adjusted to operate in the open position (mixing) from 30 seconds to 3 minutes.

Mode of Operation:

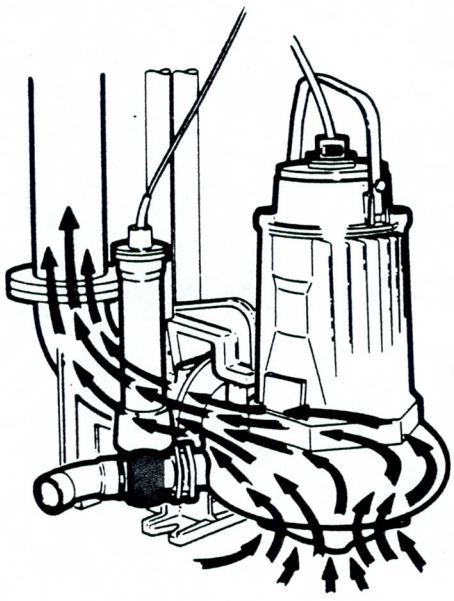
1. The Mixing Valve is open
2. The start level control starts the pump and the time relay, controlling the valve, receives an impulse.
3. As the pre-set time is reached, the Mixing Valve closes and the pump continues to operate until the sump stop level is reached.
4. The shut off level control stops the pump and opens the Mixing Valve.

Limitations:

Ambient temperature not to exceed 40°C (104°F)
Immersion depth not to exceed 5m (approximately 16.5 ft.)



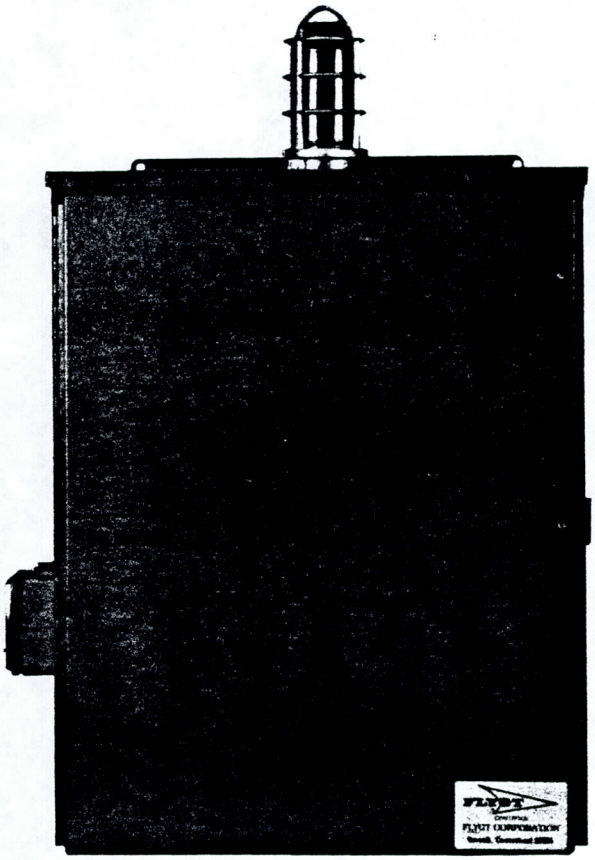
Mixing Valve **Open**



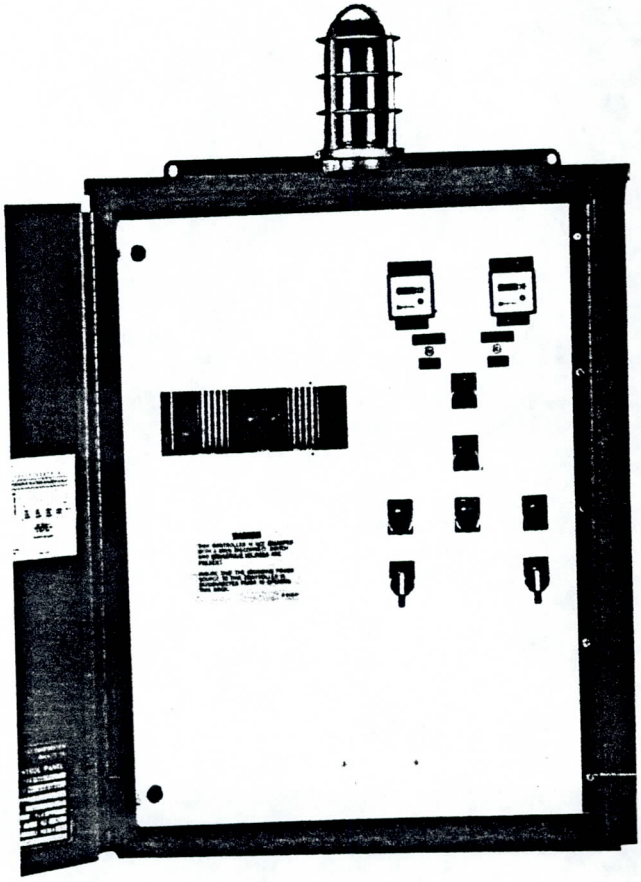
Mixing Valve **Closed**

Electrical Controls
F-3000

SECTION	PAGE
11	11
SUPERSEDES	ISSUED
2/88	6/90



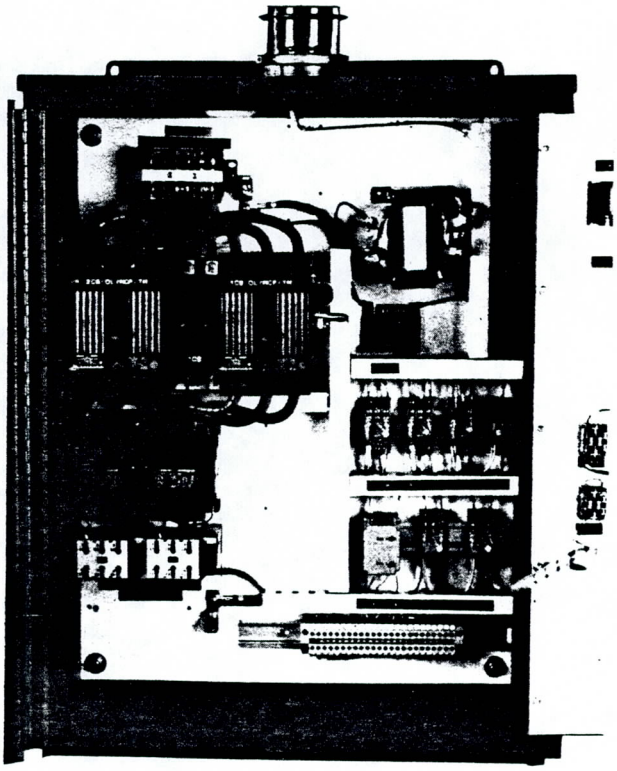
Typical NEMA 3R enclosure (rainproof and sleet-ice-resistant) UL Listed with drip shield top and seam free front, back and sides. This sturdy enclosure is constructed of 14 gauge steel with heavy duty continuous hinge. A hasp and staple assembly is provided for security padlocking. Long lasting finish of blue baked enamel over primer to the galvanized base metal provides a surface that is extremely resistant to abrasion, oxidation and corrosion.



Inside the enclosure is a 14 gauge steel hinged deadfront to which all operating controls are mounted. The controls on the deadfront allow for operation of the panel while protecting operator from the danger of accidentally coming in contact with the live circuitry. The design offers easy accessibility to the control's internal components by qualified service personnel. These components are fixed to a 12 gauge steel stud-mounted back panel. The deadfront and back panel are finished in white baked enamel.

Electrical Controls
F-3000

SECTION	PAGE
11	12
SUPERSEDES	ISSUED
2/88	6/90



Flygt offers numerous options to enhance your basic F-3000 control. Many years of experience with pumping station design have assisted Flygt in programming the many and various optional requirements desired by consultants and end-users. As is with the basic control, the options are pre-engineered to keep your cost down while still retaining the highest quality possible. By utilizing Flygt F-3000 options, you can create your own "Custom" control at "off-the-shelf" prices and delivery time.

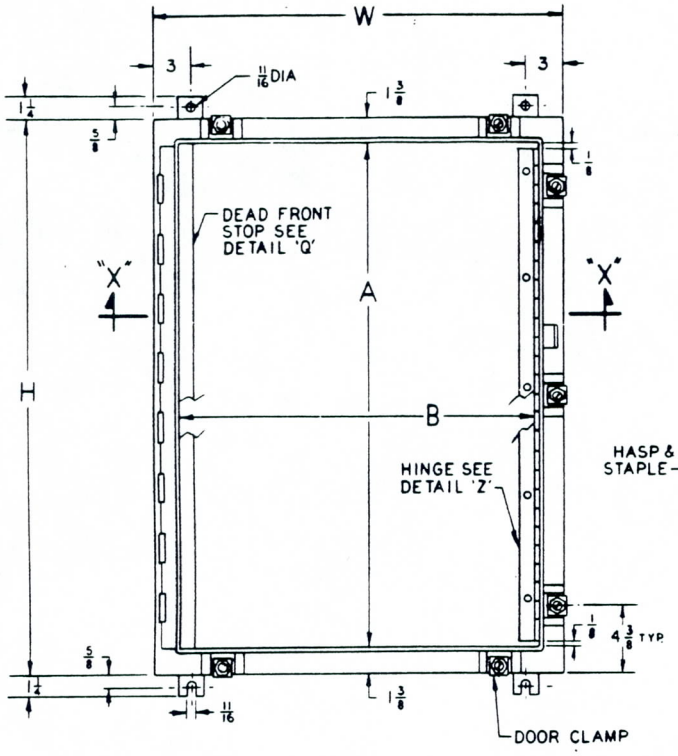
Flygt's aim is too maximize competitiveness, cost effectiveness and product performance and to minimize engineering, submittal and delivery times.

FLYGT

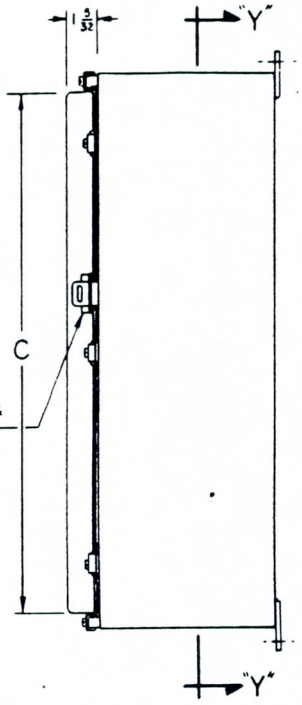
Electrical Controls

Enclosure Dimensions F-3000 NEMA 4

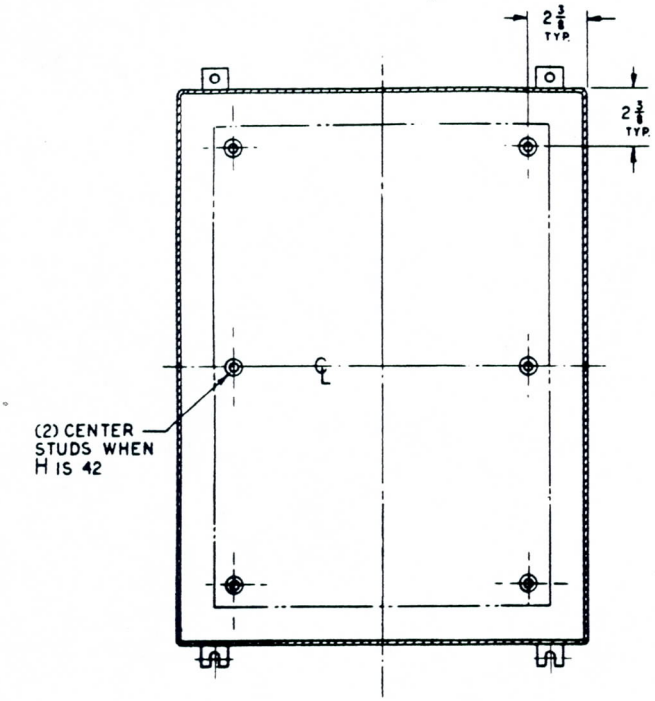
SECTION	PAGE
11	14
SUPERSEDES	ISSUED
2/88	6/90



FRONT VIEW
(DOOR REMOVED)



SIDE VIEW



SECTION "Y-Y"

ENCLOSURE NEMA – 4									
ENCLOSURE AND DETAIL DIMENSIONS									NO. OF SLOTS (HINGE)
H	W	A	B	C	D	P	L	S	
20	20	17 1/4	17 1/4	18 3/16	18 5/32	17 3/4	17	7	3
30	24	27 1/4	21 1/4	28 3/16	22 5/32	27 3/4	27	6	5
36	30	33 1/4	27 1/4	34 3/16	28 5/32	33 3/4	33	6	6
42	30	39 1/4	27 1/4	40 3/16	28 5/32	39 3/4	39	6	7
48	36	45 1/4	33 1/4	46 3/16	34 5/32	45 3/4	45	6	8

C-3170

Electrical Data

SECTION	MODEL
6	3170
SUPERSEDES	ISSUED
7/89	6/90

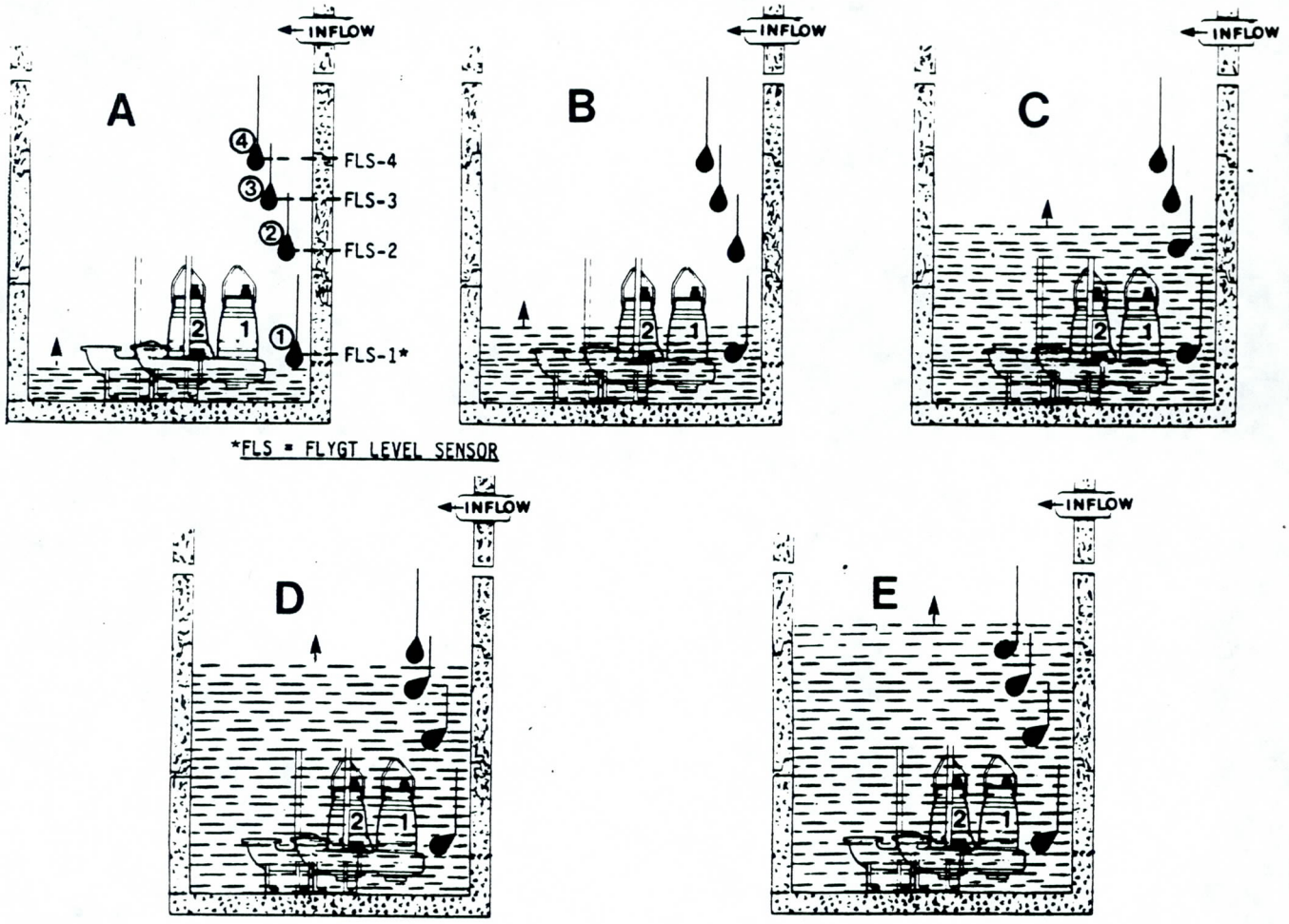
MOTOR DATA

RATED OUTPUT POWER HP (KW)	Ø	VOLTS NOM.	FULL LOAD AMPS	LOCKED ROTOR AMPS	LOCKED ROTOR KVA	LOCKED ROTOR CODE LETTER KVA/HP	RATED INPUT POWER KW	POLES/RPM
30 (22)	3	200 230 460 575	83.0 72.0 36.0 29.0	535.9 466.0 233.0 186.4	185.0	G	25	4/1740
25 (19)	3	200 230 460 575	80.0 70.0 35.0 28.0	529.0 460.0 230.0 184.0	183.0	H	22	6/1170

Pump Motor HP	EFFICIENCY			POWER FACTOR		
	100% LOAD	75% LOAD	50% LOAD	100% LOAD	75% LOAD	50% LOAD
30	86.5	86.5	85.5	0.90	0.88	0.83
25	85.5	85.0	82.0	0.80	0.74	0.62

CABLE DATA

HP	VOLTS	MAX. LENGTH FT.	CABLE SIZE	NOMINAL DIA.	CONDUCTORS (IN ONE CABLE)
30	200	290	(1) #1/3-2-1-GC	41.7 mm (1.64")	(3) #1 AWG (PWR) (2)#10 AWG (CTRL) (1) #4 AWG (GND) (1) #8 AWG (GC)
30	230 460 575	190 760 1190	(1) #4/3-2-1-GC	33.8 mm (1.33")	(3) #4 AWG (PWR) (2)#10 AWG (CTRL) (1) #6 AWG (GND) (1) #10 AWG (GC)
25	200 230 460 575	170 225 850 1500			



*FLS = FLYGT LEVEL SENSOR

A. Liquid level is below the lowest Level Sensor (FLS #1). All sensors are hanging straight in the wet well, therefore, the circuits in the sensors are not complete and no signal is being sent to the control. Both pumps OFF.

B. On rising liquid level, FLS-1 tilts and the sensor mercury switch completes the circuit sending a signal to energize the control. At this point both pumps are still in the OFF mode.

C. The liquid level has risen to a level that tilts Level Sensor #2, completing its circuit.

a) This signal to the control activates the Contactor in the control which, in turn, starts the lead pump.

b) The Level Sensor #2 also, at this time, activates the Alternator in the control which will automatically select the other pump to become the lead pump on the next start-up cycle. The selection of alternate pumps as the lead pump serves two purposes:

1) Approximately even running times (wear), thus maximizing their useful life.

2) Allows for many more starts per hour as the starting frequency is divided between the two pumps.

Should the capacity of the lead pump be <u>greater than</u> the inflow to the station, the liquid level will start to drop. The pump will continue to run (due to a holding circuit in the control) until the level drops below Sensor #1. Sensor #1, on drawdown. acts as the low level shut-off. Pump OFF.

D. This drawing shows the sequence when the capacity of the lead pump is <u>less than</u> the inflow to the station. In this case, the liquid level will gain on the pump and rise to Sensor #3 which will then send a signal to the main control starting the second or lag pump. Should their combined capacity be <u>greater than</u> the inflow, <u>both pumps</u> will continue to operate (due to the holding circuit in the control) until the liquid level drops below the low level shut off Sensor #1.

E. In the station mentioned above (both pumps operating) if the inflow to the station is <u>greater than</u> the combined capacity of both pumps, the liquid level will rise to the High Level Sensor #4. When #4 tilts, it will send a signal to an alarm system, normally an alarm bell or red alarm light. There are other options for alarm conditions such as alert by telephone, etc. In any case, the alarm system is a warning that something has happened in the station that could result in an overflow condition. This could be a control problem, one or both pumps not operating, pumps not operating up to capacity, etc. Regardless of the cause, an alarm calls for immediate action.

For most installations, the Low Level Shut-Off Sensor should be located approximately at the top of the pump volute. However, there are certain situations where maximum cooling may be required such as pumping warm liquids; in certain cases with pumps that do not have cooling jackets; some large H.P. units, etc. Also, in situations where the NPSHR requires a liquid level that is above the pump volute. When in doubt, consult Flygt Application Engineering.

<u>NOTE</u>: This sequence applies when using the Flygt 3000 Series Controls The only difference when using the former 200 Series Controls is that the alternator in the control is activated when FLS-1 tilts on rising liquid level.

SVERDRUP

JOB TOYOTA 40477 SHEET NO. 1 OF 53

DATE 8/91

COMPUTATIONS FOR ACCESS ROAD UND. PASS DRAINAGE BY BSW CHKD RVT

ACCESS ROAD INFORMATION

#1 UNDERPASS = ROAD 'H'

2% SLOPE TO EAST

20 FT WIDTH

#2 UNDERPASS = ROAD 'G-1'

2% SLOPE TO WEST

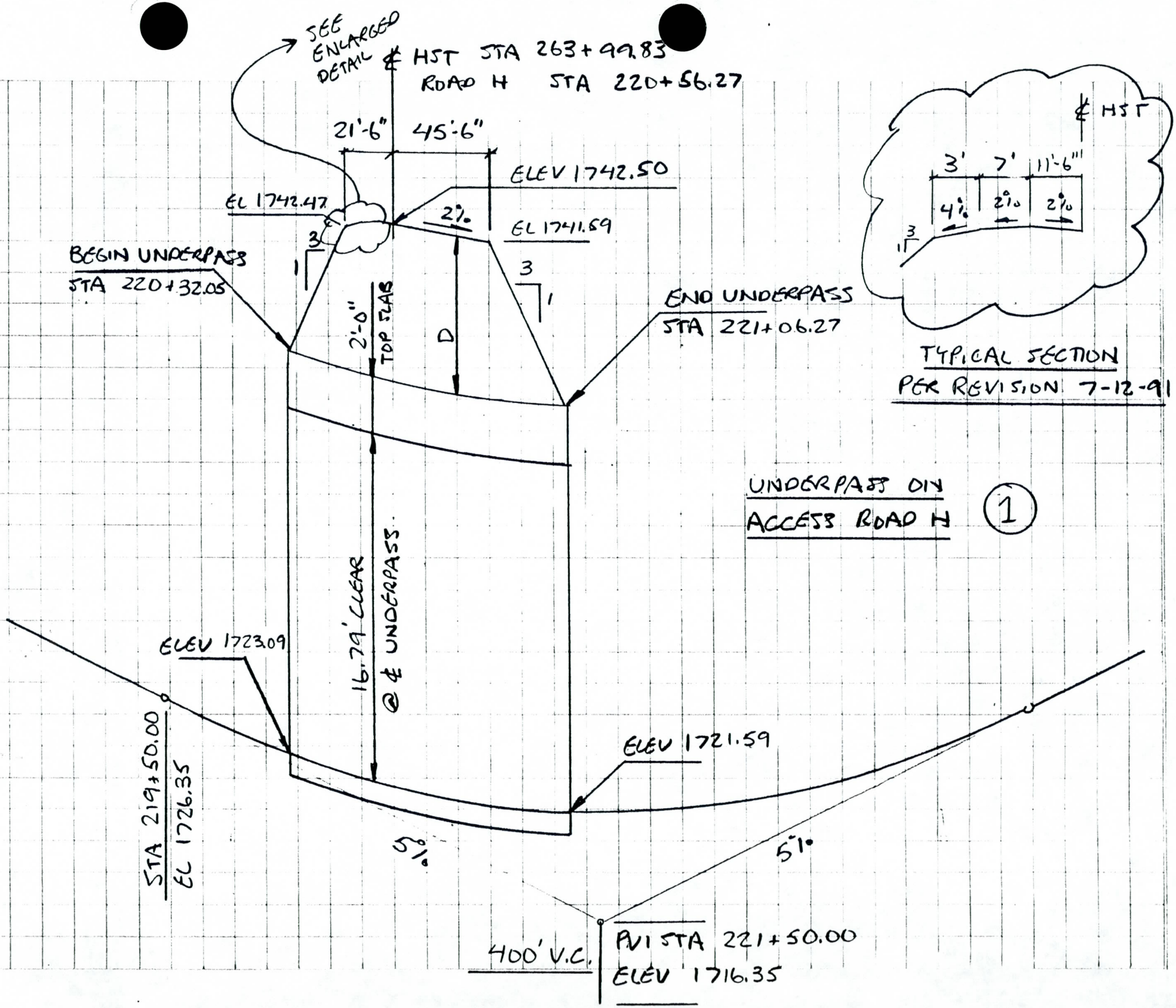
20FT WIDTH

#3 UNDERPASS = ROAD 'A-1'

2% SLOPE TO WEST

26 FT WIDTH

DESIGN FOR 10 92 STORM



TYPICAL SECTION
PER REVISION 7-12-91

UNDERPASS ON
ACCESS ROAD H (1)

SVERDRUP

JOB 40477 TOYOTA APG

COMPUTATIONS FOR UNDERPASSES

SHEET NO. 3 OF

DATE 7-91

BY RCS CHKD

SVERDRUP

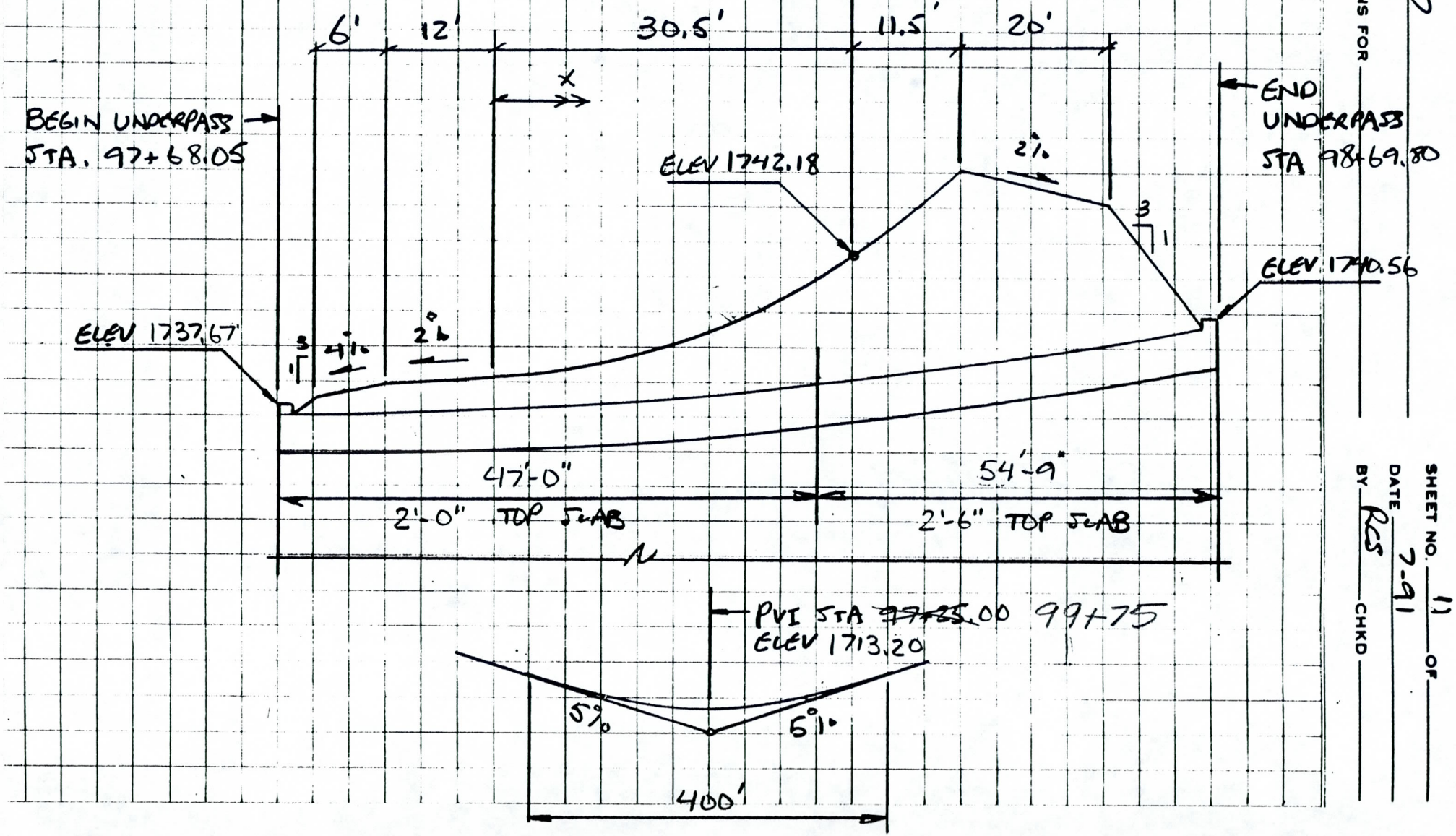
JOB 40477 SHEET NO. 11 OF

COMPUTATIONS FOR DATE 7-91

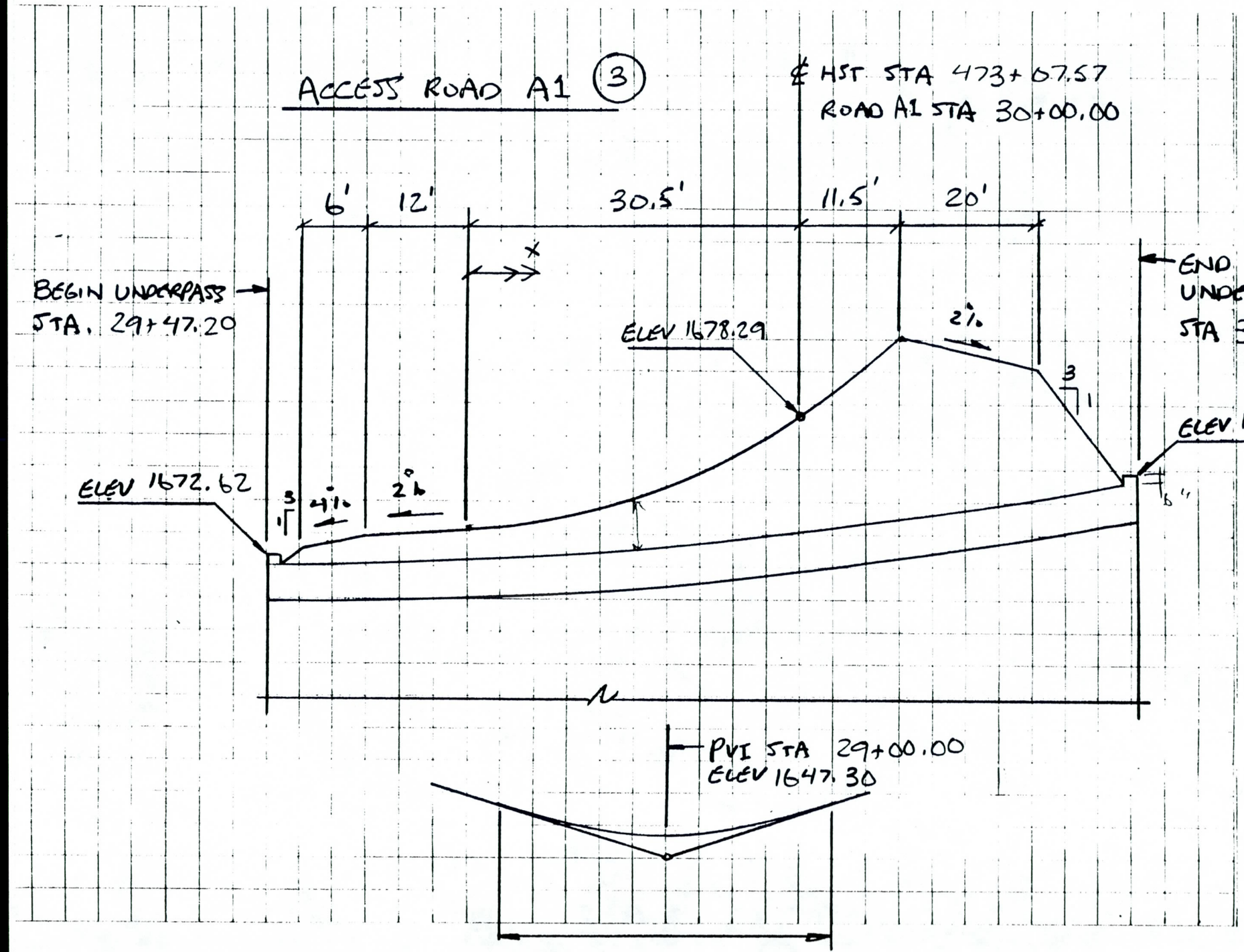
BY RCS CHKD

ACCESS ROAD G (2)

℄ HST STA 366+04.49 =
ROAD G STA ~~98+30.71~~ 100+70.70



3/53



SVERDRUP

JOB 40477

COMPUTATIONS FOR

SHEET NO. 7 OF

DATE 7-91

BY RCS CHKD

41/53

SVERDRUP

JOB 4077

COMPUTATIONS FOR A-1 UNDERPASS PROFILE

5/53

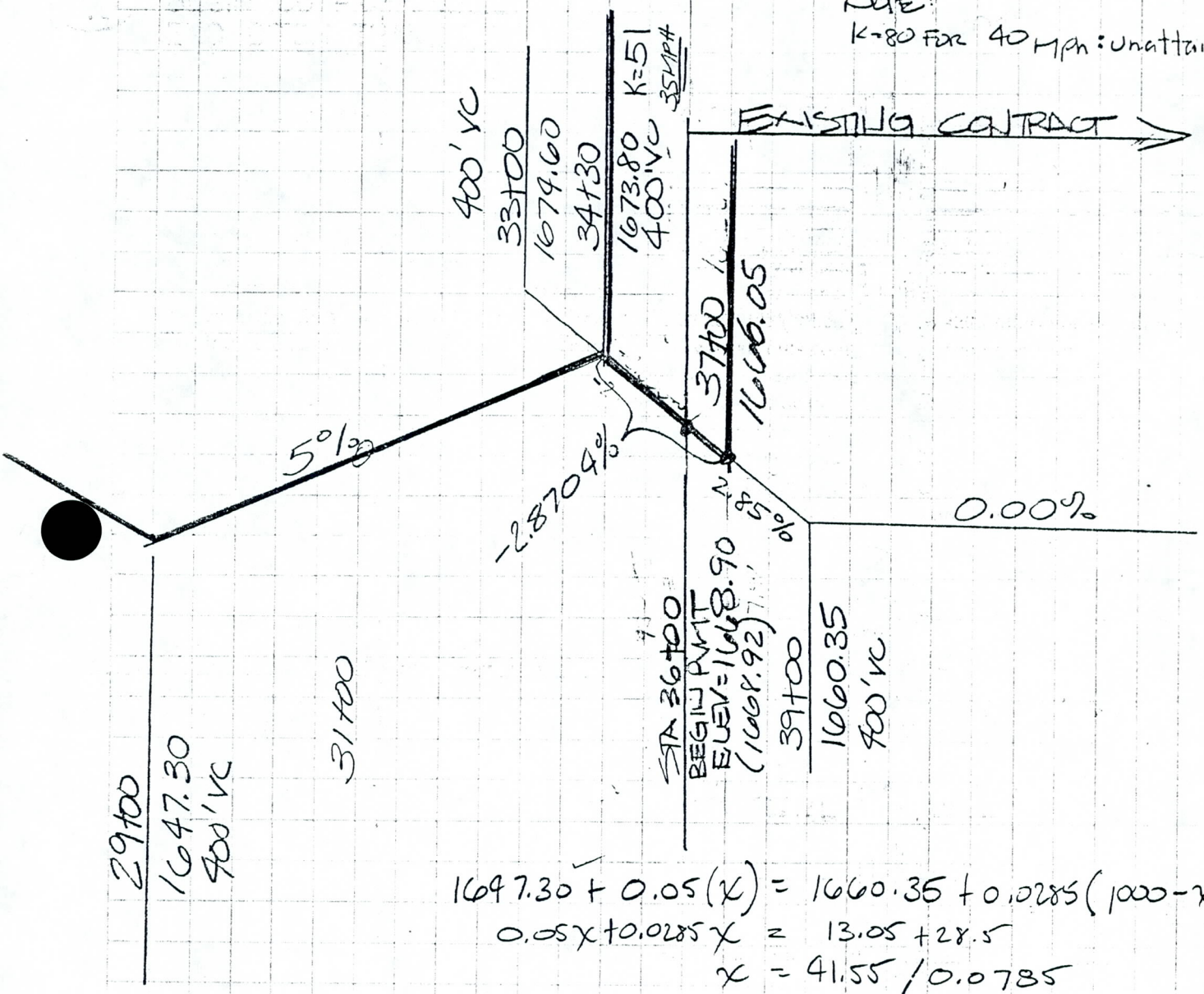
SHEET NO. 3 OF 5

DATE 7.13.91

BY REM CHKD

MATCH CURRENT ACT PROF

NOTE!
K=80 FOR 40 MPH: Unattainable



$1697.30 + 0.05(x) = 1660.35 + 0.0285(1000 - x)$

$0.05x + 0.0285x = 13.05 + 28.5$

$x = 41.55 / 0.0785$

$= 529.2994$

@ x = 525

ΔE = 26.25

Tie-in @ 36+00 (1668.90) %Grade = 2.6571

2.85% 2.66% = 0.19% VERY NEARLY MIN (0.2%) W/NO VERTICAL CURVE REQ'D

ALSO 34+25 - 36+00 = 175' NOT ENOUGH FOR 400' VC REQ'D FOR 35 MPH.

@ X = 530 ΔE = 26.5 Tie in @ 37+00

%GRADE = 2.870% ? 2.85% 0.020% GRADE BREAK Is negligible

SVERDRUP

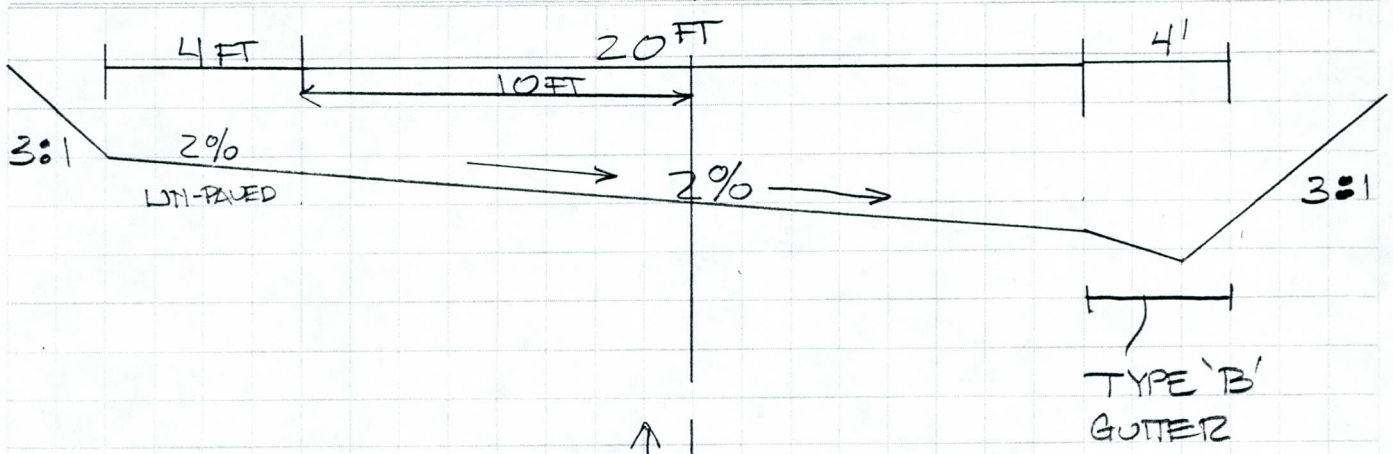
JOB TOYOTA 40477

SHEET NO. 6 OF 53

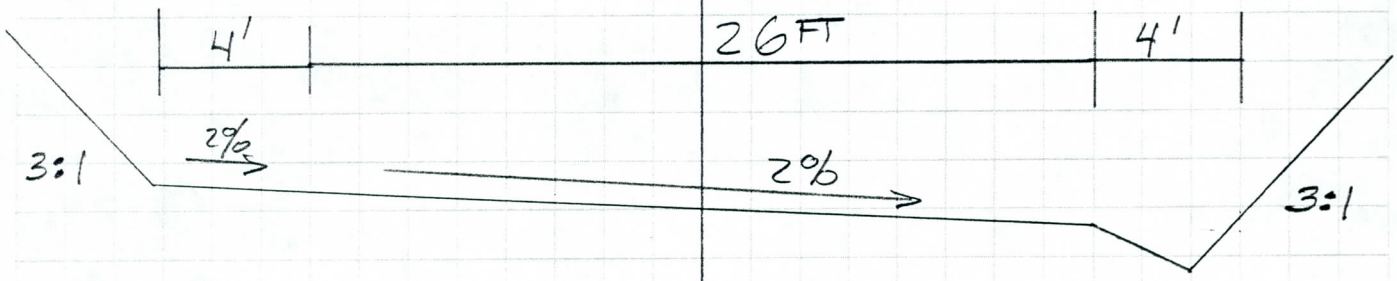
DATE 7/22/91

COMPUTATIONS FOR ACCESS ROAD TYPICAL SECTIONS

BY BSW CHKD RJT



FOR ROADS G & H
(LOOKING BACK STA.)



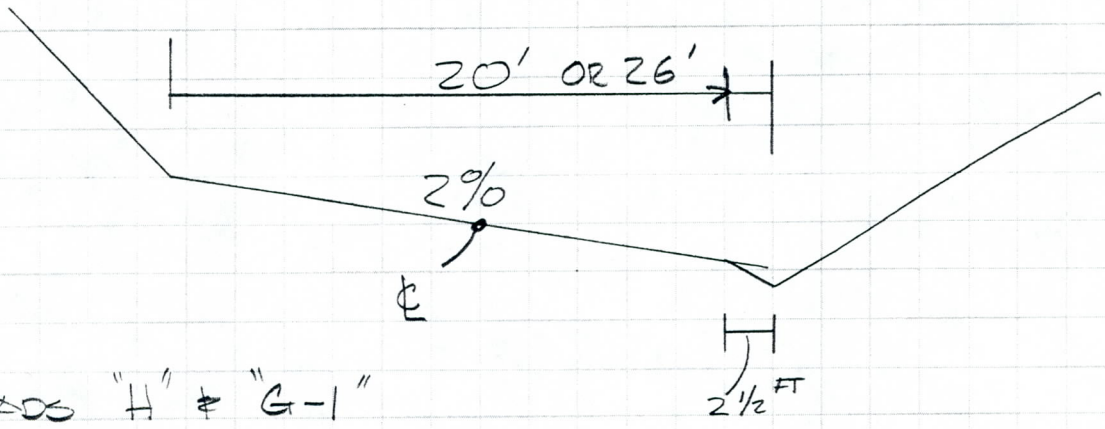
FOR ROAD A-1
(LOOKING AHEAD STA.)

SVERDRUP

JOB TOYOTA 40477 SHEET NO. 7 OF 53

DATE 8/91

COMPUTATIONS FOR ACCESS ROAD DRAIN. BY BSW CHKD RJT



ROADS "H" & "G-1"

GUTTER ELEVATION

= ℄ ELEV − 10 (.02) − 2" = ℄ ELEV − 0.3$\bar{6}$ FT

ROAD A-1

= ℄ ELEV − 13 (.02) − 2" = ℄ ELEV − 0.4$\bar{2}\bar{6}$ FT

SVERDRUP

JOB 404177 TOYOTA APG

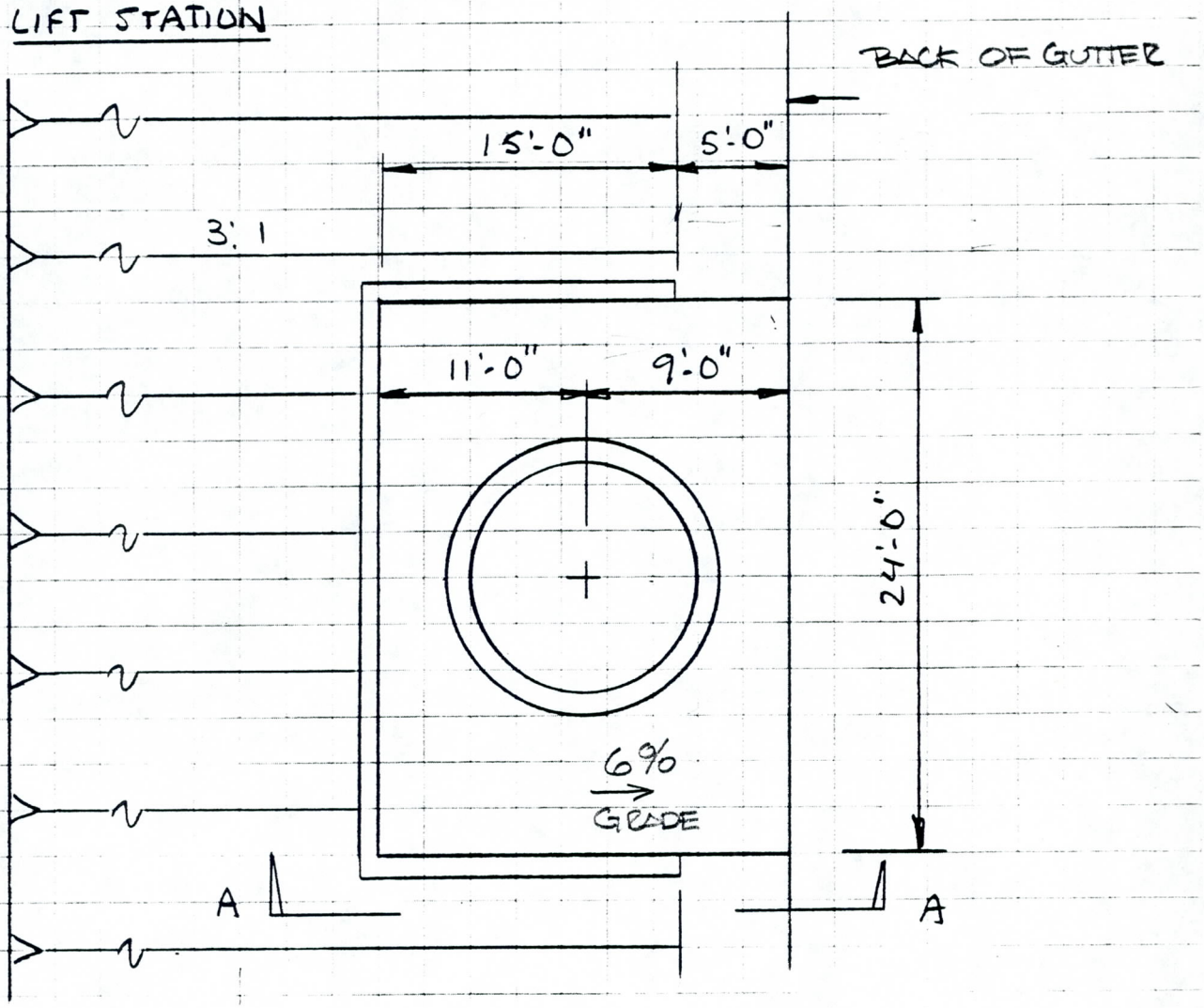
COMPUTATIONS FOR LIFT STATION

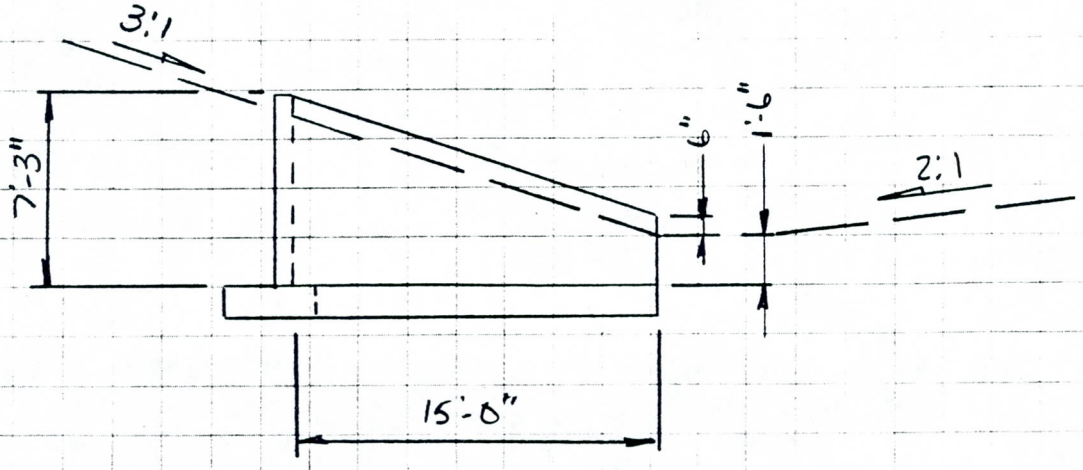
SHEET NO. _____ OF _____

DATE 7-91

BY RCS CHKD _____

RETAINING WALLS FOR LIFT STATION





SECTION A-A

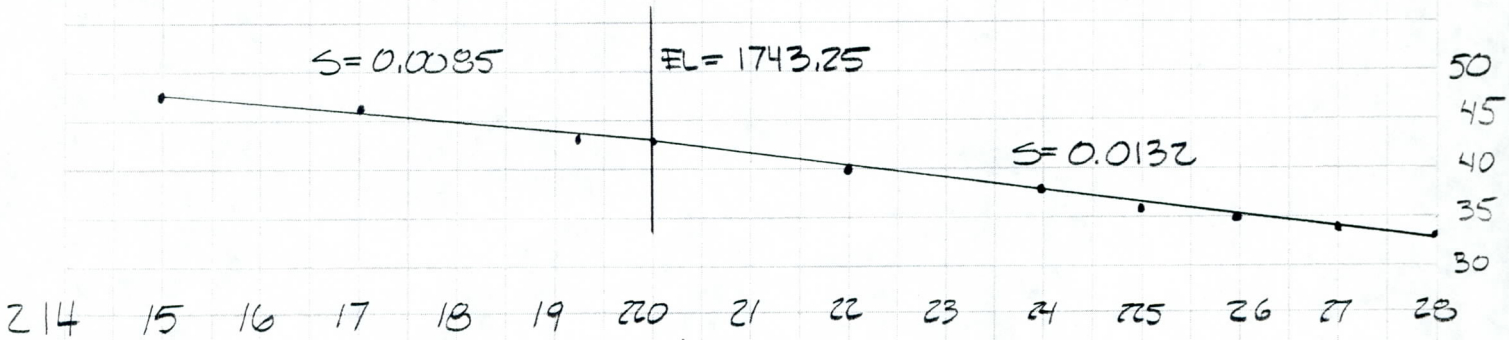
SVERDRUP

JOB 40477 UNDERPASSES SHEET NO. 9 OF 53

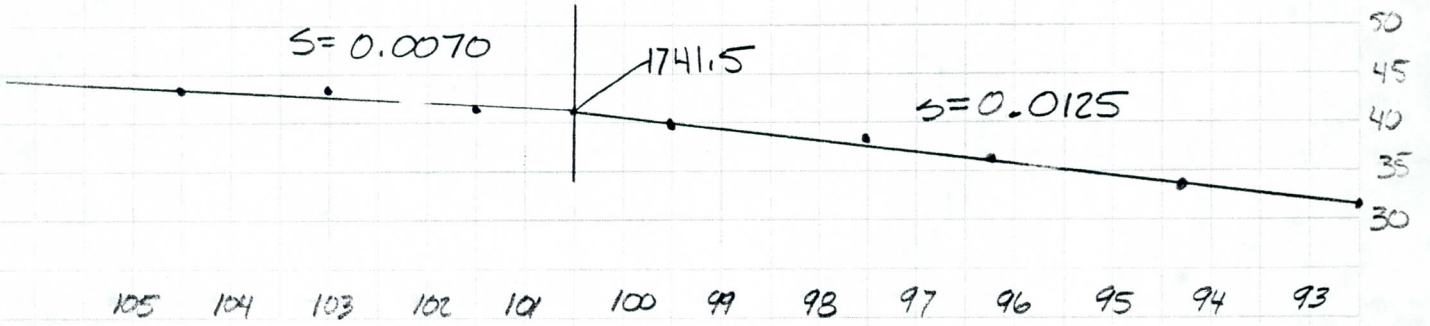
DATE 8/91

COMPUTATIONS FOR EXISTING GRADE PROFILES BY BSW CHKD RJT

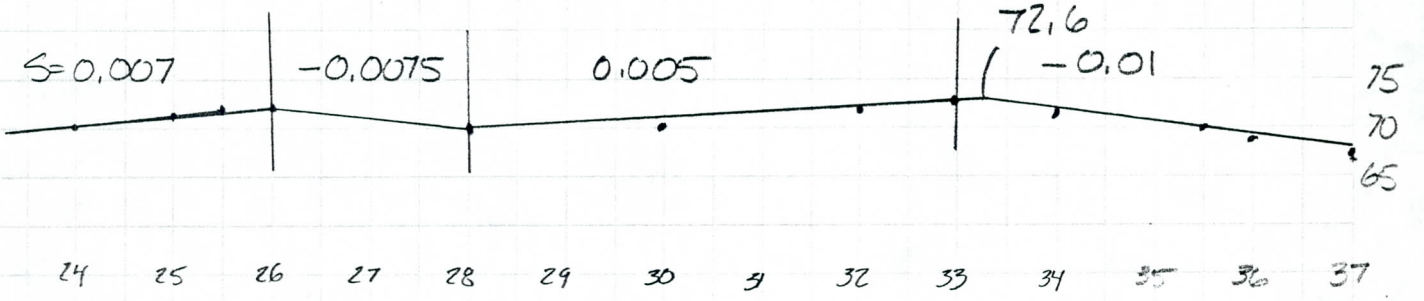
ROAD 'H'



ROAD 'G-1'



ROAD A-1



SVERDRUP

JOB Toyota. 40477 SHEET NO. 10 OF 53

COMPUTATIONS FOR ROAD 'H' PROFILE DATE 8/91 BY BSW CHKD RJT

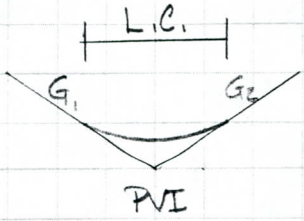
PVI ⇒ STA 221+50 (GIVEN)

ELEV 1716.35

$G_1 = -5\%$

$G_2 = 5\%$

VER. CURVE $L = 400 = LC$



FOR VERTICAL CURVES:

$$\text{RATE OF GRADE CHANGE} = r = \frac{g_2 - g_1}{LC}$$

$$= \frac{+5+5}{4} = 2.50$$

$$y_c = \left(\frac{r}{2}\right) x^2 + g_1 x + BVC_{ELEV}$$

$$BVC_{ELEV} = 1716.35 + 200(.105)$$
$$= 1726.35$$

SINCE ALIGNMENTS HAVE NOT BEEN FINALIZED, USE THE FOLLOWING PVI'S (BASED ON GRAPHICAL BEST FIT)

215+00 $G_1 = 0\%$ BVC STA = 213+00

$r = \frac{-5+0}{4} = -1.25$ $BVC_{EL} = 1716.35 + 650(.105)$
$= 1748.35$

225+75 $G_2 = -1\%$

$r = \frac{-1-5}{4} = -1.5$ $BVC_{EL} = 1716.35 + 225(.105)$
$= 1727.60$

TOYOTA
PROJECT NO. 40477
CALCULATION OF CUT DEPTH FOR UNDERPASS NO. 1. ROAD "H"

STATION	ELEVATION (C/L)		SLOPE DATA	GRADE (EXISTING)	GRADE SLOPE	C/L CUT	BASIN WIDTH	Σ AREA (ACRES)
21300	1748.85	R =	-1.25	1748.53	-0.83	0.08	28.48	0.02
21325	1748.81	BVC STA:	21300.00	1748.72		-0.09	0.00	0.02
21350	1748.69	BVC ELEV	1748.85	1748.52		-0.18	0.00	0.02
21375	1748.50	G1 =	0.00	1748.31		-0.19	0.00	0.02
21400	1748.23			1748.10		-0.12	0.00	0.02
21425	1747.87			1747.89		0.02	28.11	0.03
21450	1747.44			1747.69		0.24	29.45	0.05
21475	1746.94			1747.48		0.54	31.25	0.07
21500	1746.35			1747.27		0.92	33.52	0.09
21525	1745.69			1747.06		1.38	36.26	0.11
21550	1744.94			1746.86		1.91	39.47	0.13
21575	1744.12			1746.65		2.52	43.14	0.15
21600	1743.23			1746.44		3.22	47.29	0.18
21625	1742.25			1746.23		3.98	51.90	0.21
21650	1741.19			1746.03		4.83	56.99	0.24
21675	1740.06			1745.82		5.76	62.54	0.28
21700	1738.85			1745.61		6.76	68.56	0.32
21725	1737.60	SLOPE:	-5.00	1745.40		7.80	74.82	0.36
21750	1736.35			1745.20		8.85	81.07	0.41
21775	1735.10			1744.99		9.89	87.33	0.46
21800	1733.85			1744.78		10.93	93.58	0.51
21825	1732.60			1744.57		11.97	99.84	0.57
21850	1731.35			1744.37		13.02	106.09	0.63
21875	1730.10			1744.16		14.06	112.35	0.70
21900	1728.85			1743.95		15.10	118.60	0.76
21925	1727.60			1743.74		16.14	124.86	0.84
21950	1726.35	R =	2.50	1743.54		17.19	131.11	0.91
21975	1725.18	BVC STA:	21950.00	1743.33		18.15	136.90	0.99
22000	1724.16	BVC ELEV	1726.35	1743.08	-1.00	18.92	141.49	1.07
22025	1723.30	G1 =	-5.00	1742.83	(TRACK)	0.00	0.00	1.07
22050	1722.60			1742.58	(AREA)	0.00	0.00	1.07
22075	1722.05			1742.33	(NO)	0.00	0.00	1.07
22100	1721.66			1742.08	(RUNOFF)	0.00	0.00	1.07
22125	1721.43			1741.83		20.40	150.40	1.16
22150	1721.35	:PVI		1741.58		20.23	149.37	1.24
22175	1721.43			1741.33		19.90	147.40	1.33
22200	1721.66			1741.08		19.42	144.49	1.41
22225	1722.05			1740.83		18.77	140.65	1.49
22250	1722.60			1740.58		17.98	135.87	1.57
22275	1723.30			1740.33		17.02	130.15	1.64
22300	1724.16			1740.08		15.92	123.49	1.71
22325	1725.18			1739.83		14.65	115.90	1.78
22350	1726.35			1739.58		13.23	107.37	1.84
22375	1727.60	R =	-1.50	1739.33		11.73	98.37	1.90
22400	1728.80	BVC STA:	22375.00	1739.08		10.27	89.65	1.95
22425	1729.91	BVC ELEV	1727.60	1738.83		8.92	81.49	2.00
22450	1730.93	G1 =	5.00	1738.58		7.65	73.90	2.04
22475	1731.85			1738.33		6.48	66.87	2.08
22500	1732.68			1738.08		5.40	60.40	2.11

TOYOTA
PROJECT NO. 40477
CALCULATION OF CUT DEPTH FOR UNDERPASS NO. 1, ROAD "H"

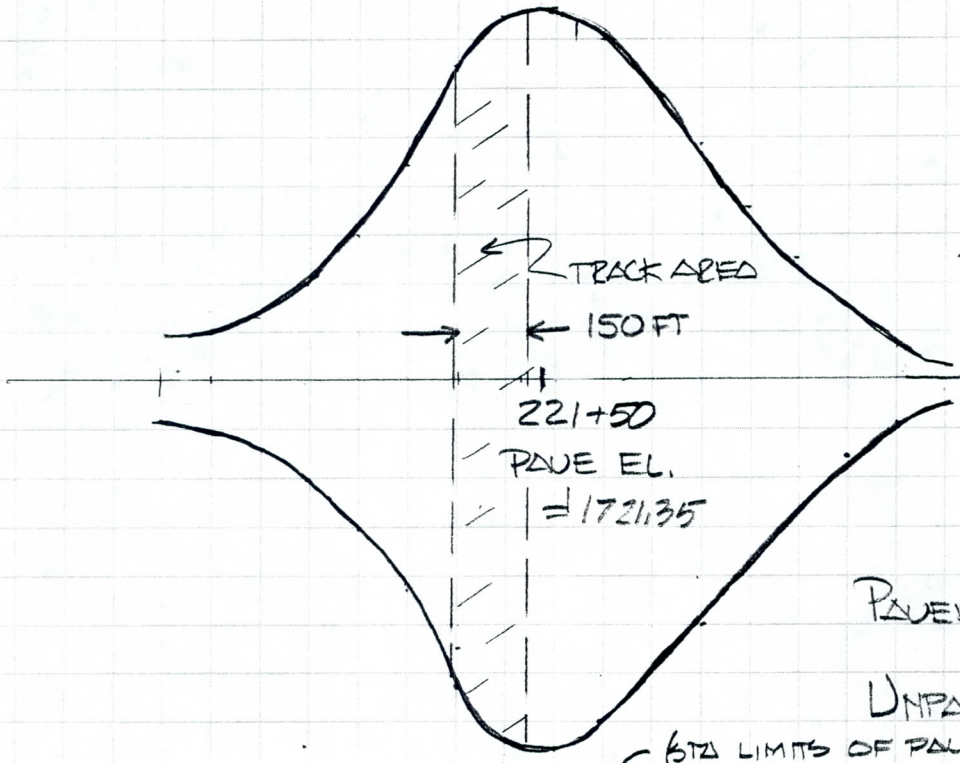
STATION	ELEVATION (C/L)	SLOPE DATA	GRADE (EXISTING)	GRADE SLOPE	C/L CUT	BASIN WIDTH	Σ AREA (ACRES)
22525	1733.41		1737.83		4.42	54.49	2.14
22550	1734.05		1737.58		3.52	49.15	2.17
22575	1734.80		1737.33		2.73	44.37	2.20
22600	1735.05		1737.08		2.02	40.15	2.22
22625	1735.41		1736.83		1.42	36.49	2.24
22650	1735.68		1736.58		0.90	33.40	2.26
22675	1735.85		1736.33		0.48	30.87	2.28
22700	1735.93		1736.08		0.15	28.90	2.29
22725	1735.91		1735.83		-0.08	0.00	2.29
22750	1735.80		1735.58		-0.23	0.00	2.29

SVERDRUP

JOB TOYOTA 40477 SHEET NO. 13 OF 53

DATE 8/91

COMPUTATIONS FOR ACCESS ROAD 'H' UNDERPASS #1 BY BHW CHKD RTT



TOTAL AREA = 2.29 ACRES

TRACK DRAINAGE WILL BE CHANNELIZED AWAY FROM THE DEPRESSED AREA.

PAVED AREA ⇒ C = 0.95

UNPAVED SLOPE C = 0.40

(STA LIMITS OF PAVE.)

TRACK AREA (LENGTH)

$$\text{AREA OF PAVE} = \frac{(21400 - 22725 - 150)\,20'}{43560} = .54 \text{ ACRES}$$

PAVE. WIDTH.

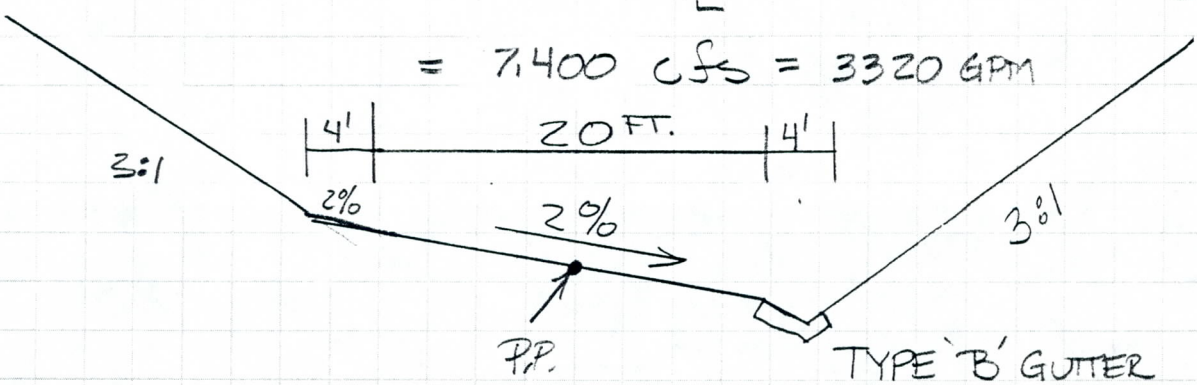
UNPAVED AREA = 2.29 − .54 = 1.75 ACRES

USE SAME HYDROLOGY AS STEEP GRADE FACILITY.

$$Q(10\text{YR}) = CiA$$

$$= (6.1 \text{ IN/HR})[(.95)(.54) + (.40)(1.75)]$$

$$= 7.400 \text{ cfs} = 3320 \text{ GPM}$$



SVERDRUP

JOB TOYOTA 40477 SHEET NO. 14 OF 53

COMPUTATIONS FOR ACCESS H DRAIN DATE 8/91

BY BSW CHKD RJT

$$Q = Ci\,A$$

$$= (6.1\ \text{IN/HR})\ C_{AVG}\ A$$

↳ SEE PREVIOUS SPREAD SHEET

$$C_{AVG} = \frac{.95(.54) + .40(1.75)}{.54 + 1.75}$$

$$\doteq 0.530$$

SIZE SLOTTED DRAIN

$$Q = \frac{1.486}{n} A\, r_h^{2/3}\, S^{1/2}$$

$$4.01 = \frac{1.486}{.024} \frac{\pi}{4} (D^2) \left(\frac{D}{4}\right)^{2/3} (.005)^{1/2}$$

$$D^{8/3} = 1.17$$

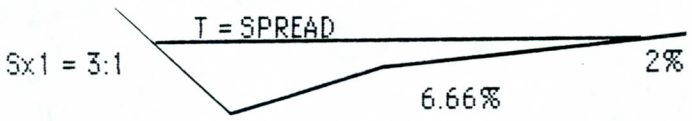
$$D = 1.06\ \text{FT} = 12.71\ \text{IN}$$

USE 18 INCH SLOTTED DRAIN.

SPREAD CALCULATIONS:

$$Q = \frac{0.56 * Sx^{1.67} * S^{0.5} * T^{2.67}}{n} \qquad \text{(EQ. 4, HEC 12)}$$

TYPICAL SECTION:



$$Sx = \frac{(Sx1)(Sx2)}{Sx1 + Sx2}$$

Sx 1 = .333
Sx 2 = VARIES, AND WILL BE SHOWN AS A WEIGHTED AVERAGE OF 6.66% & 2%
n = 0.016
S = VARIES

ROAD H STATION	DRAIN AREA (ACRES)	Q (10 YR) (CFS)	SLOPE (FT/FT)	Sx 2	Sx	SPREAD "T" (FT)
218+00	0.51	1.649	0.0500	0.057	0.049	3.70
219+00	0.76	2.457	0.0500	0.049	0.042	4.68
220+00	1.07	3.459	0.0400	0.042	0.037	6.02
221+50 (BACK)	1.24	4.009	0.0050	0.032	0.029	11.00
221+50 (AHEAD)	1.05	3.395	0.0050	0.033	0.030	10.15

LENGTH OF SLOTTED DRAIN REQUIRED ("L"):

$$L = k * Q^{0.42} * S^{0.3} * (1 / (n * Sx))^{0.6} \qquad \text{(EQ. 13, HEC 12)}$$

(k = 0.6)

with clogging factor = 50 %: L (W/CLOGGING) = L (DESIGN) / 50%

BASIN STATION	Q (10 YR) (CFS)	SLOPE (FT/FT)	Sx	L (DESIGN) (FT)	L (W/CLOG) (FT)	LENGTH INSTALLED (FT) *
221+50 (BACK)	4.009	0.005	0.029	22.00	44.0	40
221+50 (AHEAD)	3.395	0.005	0.030	20.16	40.3	40

*NOTE:
1) A DOWN STREAM CATCH BASIN WILL BE PLACED AT THE END OF EACH SLOTTED DRAIN SECTION
2) FLOW NOT COLLECTED BY THE SLOTTED DRAIN WILL BE COLLECTED BY THE CATCH BASIN (SUMP CONDITION).
3) SLOTTED DRAIN PIPES ARE MANUFACTURED FOR INCREMENT LENGTHS OF 10 FEET.

SVERDRUP

JOB TOYOTA. 40477 SHEET NO. 16 OF 53

DATE 8/91

COMPUTATIONS FOR ROAD 'G-1' PROFILE BY BSW CHKD RJT

PVI ⇒ STA 99+75
(GIVEN)

ELEV 1713.20

LC = 400 FT

BVC STATION = 97+75

ELEV = 200(.105) + 1713.20

= 1723.20

$r = \frac{+5+5}{4} = 2.50$

ASSUMED PVI'S FOR CRESTS (GRAPHICAL INSPECTION)

PVI = 95+25 $G_1 = +1.25$

BVC = 93+25

ELEV = 1713.20 + (.105)(99+75 - 93+25) - 200(.0125)

= 1733.20

$r = \frac{-5-1.25}{4} = -1.5625$

PVI = 106+50 $G_2 = 0\%$

BVC = 104+50

ELEV = 1713.20 + (.105)(104+50 - 99+75)

= 1736.95

$r = \frac{0-5}{4} = -1.25$

11/53

TOYOTA
PROJECT NO. 40477
CALCULATION OF CUT DEPTH FOR UNDERPASS NO. 2, ROAD "G-1"

STATION	ELEVATION (C/L)		SLOPE DATA	GRADE (EXISTING)	GRADE SLOPE	C/L CUT	BASIN WIDTH	Σ AREA (ACRES)
9325	1733.20	R =	-1.56	1732.50	1.20	-0.70	0.00	0.00
9350	1733.46	BVC STA:	9325.00	1732.80		-0.66	0.00	0.00
9375	1733.63	BVC ELEV	1733.20	1733.10		-0.53	0.00	0.00
9400	1733.70	G1 =	1.25	1733.40		-0.30	0.00	0.00
9425	1733.67			1733.70		0.03	0.00	0.00
9450	1733.54			1734.00		0.46	30.75	0.02
9475	1733.32			1734.30		0.98	33.90	0.04
9500	1732.99			1734.60		1.61	37.63	0.06
9525	1732.58			1734.90		2.32	41.95	0.08
9550	1732.06			1735.20		3.14	46.86	0.11
9575	1731.44			1735.50		4.06	52.35	0.14
9600	1730.73			1735.80		5.07	58.42	0.17
9625	1729.92			1736.10		6.18	65.09	0.21
9650	1729.01			1736.40		7.39	72.34	0.25
9675	1728.00			1736.70		8.70	80.17	0.30
9700	1726.90			1737.00		10.10	88.59	0.35
9725	1725.70			1737.30		11.60	97.60	0.40
9750	1724.45	SLOPE:	-5.00	1737.60		13.15	106.90	0.47
9775	1723.20	R =	2.50	1737.90		14.70	116.20	0.53
9800	1722.03	BVC STA:	9775.00	1738.20		16.17	125.03	0.60
9825	1721.01	BVC ELEV	1723.20	1738.50		17.49	132.92	0.68
9850	1720.15	G1 =	-5.00	1738.80		18.65	139.88	0.76
9875	1719.45			1739.10		19.65	145.90	0.85
9900	1719.90			1739.40		20.50	150.98	0.93
9925	1718.51			1739.70		21.19	155.12	1.02
9950	1718.38			1740.00		21.72	158.33	1.11
9975	1718.20	:PVI		1740.30		22.10	160.60	1.20
10000	1718.28			1740.49	0.75	22.21	161.26	1.30
10025	1718.51			1740.67	(TRACK)	0.00	0.00	1.30
10050	1718.90			1740.86	(AREA)	0.00	0.00	1.30
10075	1719.45			1741.05	(NO)	0.00	0.00	1.30
10100	1720.15			1741.24	(RUNOFF)	0.00	0.00	1.30
10125	1721.01			1741.42		20.41	150.47	1.38
10150	1722.03			1741.61		19.58	145.51	1.47
10175	1723.20			1741.80		18.60	139.60	1.55
10200	1724.45	SLOPE:	5.00	1741.99		17.54	133.22	1.62
10225	1725.70			1742.17		16.47	126.85	1.70
10250	1726.95			1742.36		15.41	120.47	1.76
10275	1728.20			1742.55		14.35	114.10	1.83
10300	1729.45			1742.74		13.29	107.72	1.89
10325	1730.70			1742.92		12.22	101.35	1.95
10350	1731.95			1743.11		11.16	94.97	2.00
10375	1733.20			1743.30		10.10	88.60	2.06
10400	1734.45			1743.49		9.04	82.22	2.10
10425	1735.70			1743.67		7.97	75.85	2.15
10450	1736.95	R =	-1.25	1743.86		6.91	69.47	2.19
10475	1738.16	BVC STA:	10450.00	1744.05		5.69	63.33	2.22
10500	1739.29	BVC ELEV	1736.95	1744.24		4.94	57.66	2.26
10525	1740.35	G1 =	5.00	1744.42		4.08	52.46	2.29

TOYOTA
PROJECT NO. 40477
CALCULATION OF CUT DEPTH FOR UNDERPASS NO. 2, ROAD "G-1"

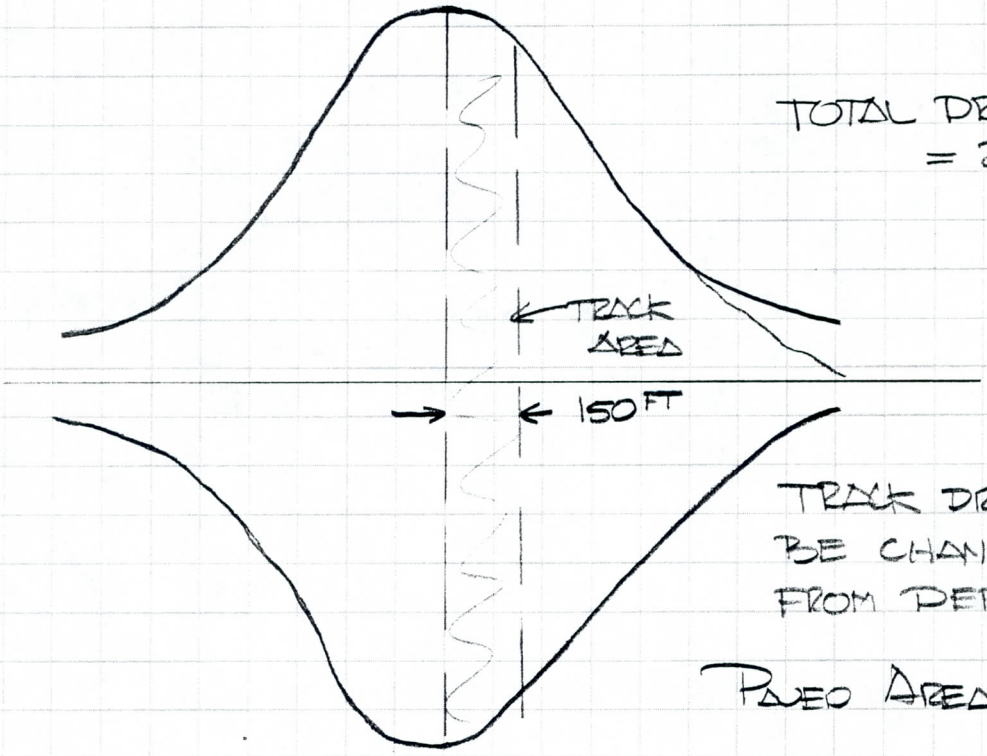
STATION	ELEVATION (C/L)	SLOPE DATA	GRADE (EXISTING)	GRADE SLOPE	C/L CUT	BASIN WIDTH	Σ AREA (ACRES)
10550	1741.33		1744.61		3.29	47.72	2.31
10575	1742.22		1744.80		2.58	43.46	2.34
10600	1743.04		1744.99		1.94	39.66	2.36
10625	1743.79		1745.17		1.39	36.33	2.38
10550	1744.45		1745.36		0.91	33.47	2.40
10575	1745.04		1745.55		0.51	31.08	2.42
10700	1745.54		1745.74		0.19	29.16	2.44
10725	1745.97		1745.92		-0.05	0.00	2.44
10750	1746.33		1746.11		-0.21	0.00	2.44
10775	1746.60		1746.30		-0.30	0.00	2.44
10800	1746.79		1746.49		-0.31	0.00	2.44
10825	1746.91		1746.67		-0.24	0.00	2.44
10850	1746.91		1746.86		-0.05	0.00	2.44

SVERDRUP

JOB TOYOTA 40477 SHEET NO. 19 OF 53

DATE 8/91

COMPUTATIONS FOR ACCESS ROAD G-1 UNDERPASS #2 BY BGW CHKD RJT



TOTAL DRAIN. AREA = 2.44 ACRES

TRACK DRAINAGE WILL BE CHANNELED AWAY FROM DEPRESSED AREA

PAVED AREA ⇒ C = 0.95

UNPAVED SLOPE C = 0.40

PAVEMENT AREA = $\dfrac{20' (107+25 - 94+25 - 150)}{43560}$ = .53 AC.

(20' = ACCESS ROAD WIDTH; 107+25 − 94+25 = PAVE. STA LIMITS; 150 = LENGTH COVERED BY TRACK)

UNPAVED AREA = 2.44 − .53 = 1.91 AC.

USING SAME HYDROLOGY AS STEEP GRADE FACILITY

$Q(10\,YR) = C\,i\,A$

$= (6.1\ IN/HR)\left[(.95)(.53) + (.40)(1.91)\right]$

$= 7.73\ cfs = 3{,}470\ gal/min.$

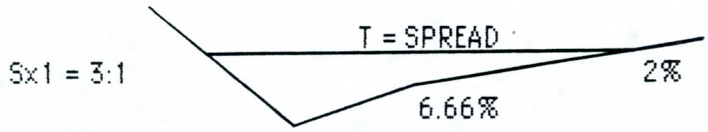
$C_{AVG} = \dfrac{.95(.53) + .40(1.91)}{.53 + 1.91} = 0.519$

$\cong \underline{0.52}$

SPREAD CALCULATIONS:

$$Q = \frac{0.56 * Sx^{1.67} * S^{0.5} * T^{2.67}}{n}$$ (EQ. 4, HEC 12)

TYPICAL SECTION:



$$Sx = \frac{(Sx1)(Sx2)}{Sx1 + Sx2}$$

Sx 1 = .333
Sx 2 = VARIES, AND WILL BE SHOWN AS A WEIGHTED AVERAGE OF 6.66% & 2%
n = 0.016
S = VARIES

ROAD G-1 STATION	DRAIN AREA (ACRES)	Q (10 YR) (CFS)	SLOPE (FT/FT)	Sx 2	Sx	SPREAD "T" (FT)
105+50	0.13	0.412	0.0500	0.067	0.056	2.02
103+50	0.44	1.396	0.0500	0.061	0.052	3.34
101+50	0.97	3.077	0.0400	0.043	0.038	5.65
99+75 (AHEAD)	1.24	3.933	0.0050	0.032	0.029	10.90
99+75 (BACK)	1.20	3.806	0.0050	0.032	0.029	10.73

LENGTH OF SLOTTED DRAIN REQUIRED ("L"):

$$L = k * Q^{0.42} * S^{0.3} * (1 / (n * Sx))^{0.6}$$ (EQ. 13, HEC 12)

(k = 0.6)

with clogging factor = 50 %: L (W/CLOGGING) = L (DESIGN) / 50%

BASIN STATION	Q (10 YR) (CFS)	SLOPE (FT/FT)	Sx	L (DESIGN) (FT)	L (W/CLOG) (FT)	LENGTH INSTALLED (FT) *
99+75 (AHEAD)	3.933	0.005	0.029	21.78	43.6	40
99+75 (BACK)	3.806	0.005	0.029	21.41	42.8	40

*NOTE:

1) A DOWN STREAM CATCH BASIN WILL BE PLACED AT THE END OF EACH SLOTTED DRAIN SECTION
2) FLOW NOT COLLECTED BY THE SLOTTED DRAIN WILL BE COLLECTED BY THE CATCH BASIN (SUMP CONDITION).
3) SLOTTED DRAIN PIPES ARE MANUFACTURED FOR INCREMENT LENGTHS OF 10 FEET.

PVI ⇒ STA: 29+00.00

ELEV = 1647.30

V.C. LC = 400 FT

BVC STA = 27+00

BVC ELEV. = 1647.30 + 200(.05)
= 1657.30

$r = \frac{5+5}{4} = 2.50$

ASSUMED PVI FOR CRESTS

PVI = 36+30

BVC STA: 34+30
ELEV = 1647.30 + (.05)(34+30 − 29+00)
= 1673.80

$G_1 = 5\%$
$G_2 = -2.8704$

$r = \frac{-5-2.8704}{4} = -1.9676$

PVI = 24+25 $G_1 = 0\%$

BVC STA: 22+25
ELEV = 1647.30 + (.05)(29+00 − 24+25)
= 1671.05

TOYOTA
PROJECT NO. 40477
CALCULATION OF CUT DEPTH FOR UNDERPASS NO. 3. ROAD "A-1"

STATION	ELEVATION (C/L)		SLOPE DATA	GRADE (EXISTING)	GRADE DATA	C/L CUT	BASIN WIDTH	ΣAREA (ACRES
2225	1671.05	R =	-1.25	1670.00	0.70	-1.05	0.00	0.00
2250	1671.01	BVC STA:	2225.00	1670.18		-0.84	0.00	0.00
2275	1670.69	BVC ELEV	1671.05	1670.35		-0.54	0.00	0.00
2300	1670.70	G1 =	0.00	1670.52		-0.17	0.00	0.00
2325	1670.43			1670.70		0.27	35.65	0.02
2350	1670.07			1670.87		0.80	38.81	0.04
2375	1669.64			1671.05		1.41	42.44	0.07
2400	1669.14			1671.22		2.09	46.53	0.09
2425	1668.55			1671.40		2.85	51.10	0.12
2450	1667.89			1671.57		3.69	56.13	0.16
2475	1667.14			1671.75		4.61	61.64	0.19
2500	1666.32			1671.92		5.60	67.61	0.23
2525	1665.43			1672.10		6.67	74.05	0.27
2550	1664.45			1671.91	-0.75	7.46	78.78	0.32
2575	1663.39			1671.72		8.33	83.99	0.37
2600	1662.26			1671.54		9.28	89.66	0.42
2625	1661.05			1671.35		10.30	95.80	0.47
2650	1659.80	SLOPE:	-5	1671.16		11.36	102.17	0.53
2675	1658.55			1670.97		12.42	108.55	0.59
2700	1657.30	R =	2.50	1670.79		13.49	114.92	0.66
2725	1656.13	BVC STA:	2700.00	1670.60		14.47	120.83	0.73
2750	1655.11	BVC ELEV	1657.30	1670.41		15.30	125.80	0.80
2775	1654.25	G1 =	-5.00	1670.22		15.97	129.83	0.87
2800	1653.55			1670.35	0.50	16.80	134.80	0.95
2825	1653.00			1670.47		17.47	138.83	1.03
2850	1652.61			1670.60		17.99	141.92	1.11
2875	1652.38			1670.72		18.35	144.08	1.20
2900	1652.30	:PVI		1670.85		18.55	145.30	1.28
2925	1652.38			1670.97		18.60	145.58	1.36
2950	1652.61			1671.10	(TRACK)	0.00	0.00	1.36
2975	1653.00			1671.22	(AREA)	0.00	0.00	1.36
3000	1653.55			1671.35	(NO)	0.00	0.00	1.36
3025	1654.25			1671.47	(RUNOFF)	0.00	0.00	1.36
3050	1655.11			1671.60		16.49	132.92	1.44
3075	1656.13			1671.72		15.60	127.58	1.51
3100	1657.30			1671.85		14.55	121.30	1.58
3125	1658.55	SLOPE:	5.00	1671.97		13.42	114.55	1.65
3150	1659.80			1672.10		12.30	107.80	1.71
3175	1661.05			1672.22		11.17	101.05	1.77
3200	1662.30			1672.35		10.05	94.30	1.82
3225	1663.55			1672.47		8.92	87.55	1.87
3250	1664.76	R =	-1.97	1672.60		7.84	81.04	1.92
3275	1665.85	BVC STA:	3230.00	1672.72		6.87	75.25	1.96
3300	1666.82	BVC ELEV	1663.80	1672.85		6.03	70.19	2.00
3325	1667.66	G1 =	5.00	1672.60	-1.00	4.94	63.63	2.04
3350	1668.38			1672.35		3.97	57.80	2.07
3375	1668.98			1672.10		3.12	52.71	2.10
3400	1669.46			1671.85		2.39	48.36	2.13
3425	1669.81			1671.60		1.79	44.75	2.16

TOYOTA
PROJECT NO. 40477
CALCULATION OF CUT DEPTH FOR UNDERPASS NO. 3. ROAD "A-1"

STATION	ELEVATION (C/L)		SLOPE DATA	GRADE (EXISTING)	GRADE DATA	C/L CUT	BASIN WIDTH	Σ AREA (ACRES)
3450	1670.04			1671.35		1.31	41.87	2.16
3475	1670.14	:CREST		1671.10		0.96	39.73	2.20
3500	1670.13			1670.85		0.72	38.33	2.22
3525	1669.99			1670.60		0.61	37.67	2.25
3550	1669.73			1670.35		0.62	37.74	2.27
3575	1669.34			1670.10		0.76	38.56	2.29
3600	1668.83			1669.85		1.02	40.11	2.31
3625	1668.20			1669.60		1.40	42.40	2.34
3630	1668.06	SLOPE:	-2.8704	1669.55		1.49	42.96	2.36
3655	1667.34			1669.30		1.96	45.77	2.39
3680	1666.62			1669.05		2.43	48.57	2.42
3700	1666.05			1668.85		2.80	50.82	2.44
3725	1665.33			1668.60		3.27	53.62	2.46

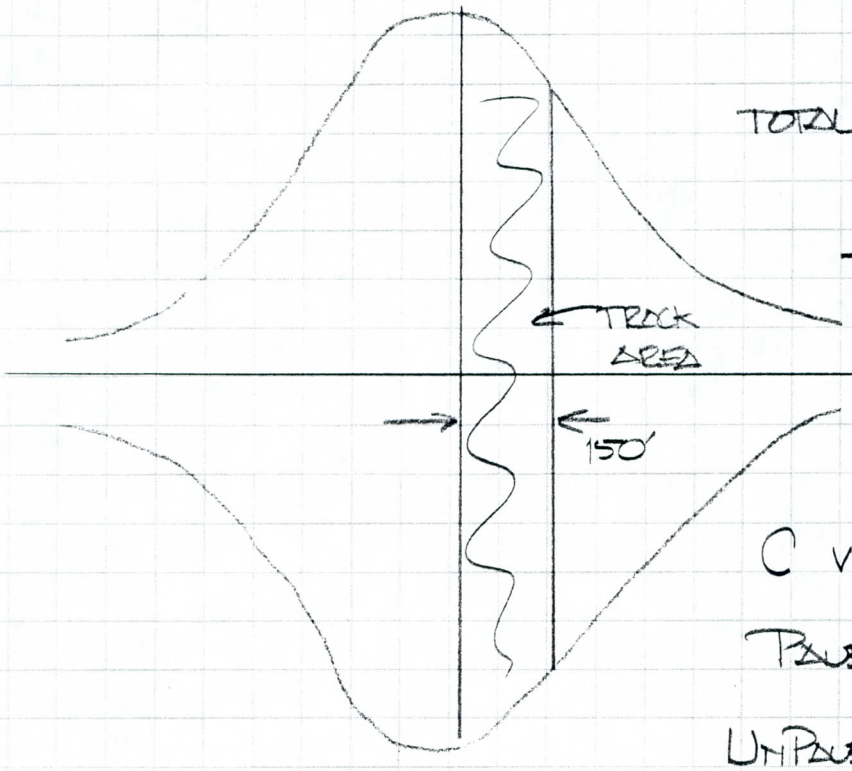
SVERDRUP

JOB Toyota 40477 SHEET NO. 24 OF 53

DATE 8/91

COMPUTATIONS FOR Access Road A-1 BY BSW CHKD RJT

Underpass #3



TOTAL DRAIN. BASIN AREA = 2.20 ACRES

TRACK AREA DRAINAGE WILL BE CHANNELED AWAY FROM THE DEPRESSED AREA

C VALUES

PAVE ⇒ C = 0.95

UNPAVED ⇒ C = 0.40

$$\text{PAVEMENT AREA} = \frac{26' \text{ (ACCESS ROAD WIDTH)} \times (3475 - 2325 - 150)\text{ (STA LIMITS OF ACCESS ROAD; LENGTH COVERED BY TRACK AREA)}}{43{,}560} = .160 \text{ ACR.}$$

UNPAVED AREA = 2.20 − .60 = 1.60 ACRES

USE SAME HYDROLOGY AS STEEP GRADE FACILITY.

$$Q(10\,YR) = CiA$$

$$= (6.1 \text{ IN/HR})\left[\frac{(.95)(.60) + (.40)(1.60)}{}\right]$$

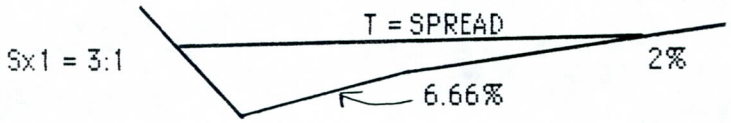
$$= 7.38 \text{ cfs} = 3313 \text{ gpm}$$

$$C_{AVG} = \frac{(.95)(.60) + (.40)(1.60)}{2.20} = 0.55$$

SPREAD CALCULATIONS:

$$Q = \frac{0.56 * Sx^{1.67} * S^{0.5} * T^{2.67}}{n}$$ (EQ. 4, HEC 12)

TYPICAL SECTION:



$$Sx = \frac{(Sx1)(Sx2)}{Sx1 + Sx2}$$

Sx 1 = .333
Sx 2 = VARIES, AND WILL BE SHOWN AS A WEIGHTED AVERAGE OF 6.66% & 2%
n = 0.016
S = VARIES

ROAD A-1 STATION	DRAIN AREA (ACRES)	Q (10 YR) (CFS)	SLOPE (FT/FT)	Sx 2	Sx	SPREAD "T" (FT)
26+00	0.42	1.409	0.0500	0.061	0.052	3.36
27+00	0.66	2.214	0.0500	0.050	0.044	4.41
28+00	0.95	3.187	0.0400	0.043	0.038	5.76
29+00 (BACK)	1.28	4.294	0.0050	0.031	0.029	11.37
29+00 (AHEAD)	0.92	3.087	0.0050	0.033	0.030	9.69

LENGTH OF SLOTTED DRAIN REQUIRED ("L"):

$$L = k * Q^{0.42} * S^{0.3} * (1 / (n * Sx))^{0.6}$$ (EQ. 13, HEC 12)

(k = 0.6)

with clogging factor = 50 %: L (W/CLOGGING) = L (DESIGN) / 50%

BASIN STATION	Q (10 YR) (CFS)	SLOPE (FT/FT)	Sx	L (DESIGN) (FT)	L (W/CLOG) (FT)	LENGTH INSTALLED (FT) *
29+00 (BACK)	4.294	0.005	0.029	22.79	45.6	40
29+00 (AHEAD)	3.087	0.005	0.030	19.18	38.4	40

*NOTE:

1) A DOWN STREAM CATCH BASIN WILL BE PLACED AT THE END OF EACH SLOTTED DRAIN SECTION
2) FLOW NOT COLLECTED BY THE SLOTTED DRAIN WILL BE COLLECTED BY THE CATCH BASIN (SUMP CONDITION).
3) SLOTTED DRAIN PIPES ARE MANUFACTURED FOR INCREMENT LENGTHS OF 10 FEET.

SVERDRUP

JOB Toyota, 40477 SHEET NO. 26 OF 53

COMPUTATIONS FOR Underpass Drain. DATE 8/91

BY BGW CHKD RJT

Lift Station Pump Size — Underpass No

		#1	#2	#3
Check Requirements for a Q ≥ (10 yr storm)	(cfs)	7.40	7.73	7.38
For each of 2 pumps (GPM)	(cfs)	3.70	3.865	3.69
$= (Q/2)\ 448.8$ gpm	(GPM)	1661	1735	1656

Size Discharge Pipe:

$$Q = VA$$

$$= (8\ FT/SEC)\left(\frac{\pi}{4} D^2\right)$$

↑ Avg for design use

$$D = \left(4Q/8\pi\right)^{1/2}$$

9.21"	9.141"	9.19"
Use 10"	Use 10"	Use 10"

Discharge Pipe Size

$$D = \left(\frac{4Q_{(SYS)}}{8\pi}\right)^{1/2}$$

13.02"	13.31"	13.01"
Use 16"	Use 16"	Use 16"

Check ponding if same pumps are used as steep grade fac

If ponding is not significant, use the same lift station.

SVERDRUP

JOB TOYOTA 40477 SHEET NO. 27 OF 53

COMPUTATIONS FOR UNDERPASS DRAIN. DATE 8/91

BY BGW CHKD RJT

VOLUME CALCULATIONS FOR STORAGE

ASSUME: USING SAME PUMPS AS STEEP GRADE (S.G.) FACILITY

SAME WETWELL DESIGN AS S.G.

(8FT) DIA WETWELL

STORAGE FOR PUMP 1 TO TURN ON:

$= 5\,FT\left(\frac{\pi}{4}\right)(8)^2 = 251\,FT^3$

$= 1880\,GAL$

TOTAL STORAGE FOR LAG PUMP TO TURN ON:

$= 1880\,GAL = 251$ $= 251\,FT^3$

WETWELL $= (2\,FT)\left(\frac{\pi}{4}\right)8^2$ $= 100.5$

PIPE $= \frac{2}{3}\left(\frac{\pi}{4}\right)(2^2)(5)$ $= 10.5$

CATCH BASIN $= 3\times3\times1$ $= 9$

$371\,FT^3$

$= 2775\,GAL$

TOTAL STORAGE BEFORE PONDING:

$= 371$ (PREVIOUS &) $= 371\,FT^3$

$+ (2.5)\left[\frac{\pi}{4}8^2\right]$ (WETWELL) $= 125.7$

$+ \frac{1}{3}\left(\frac{\pi}{4}\right)(2^2)(5)$ (PIPE) $= 5.2$

$+ 2.5\times3\times3$ (C.B.) $= 22.5$

$524.4\,FT^3$

$= 3922\,GALL.$

SVERDRUP

JOB Toyota, 40477 SHEET NO. 28 OF 53

COMPUTATIONS FOR Underpass Drain. DATE 8/91

BY BSW CHKD RJT

Pump Criteria

Avg Elevation Head: (Pump El to Outfall)

Road H: 1738 − 1711.5 = 26.5′ Use 27′

Road G-1: 1737 − 1708.34 = 28.66′ Use 29′

Road A-1: 1665.90 − 1642.38 = 23.52 Use 24′

Use similar values as the S.G. facility for velocity & friction head since outfalls are similar in configuration

Velocity H = 1 ft Friction ≅ 15 ft

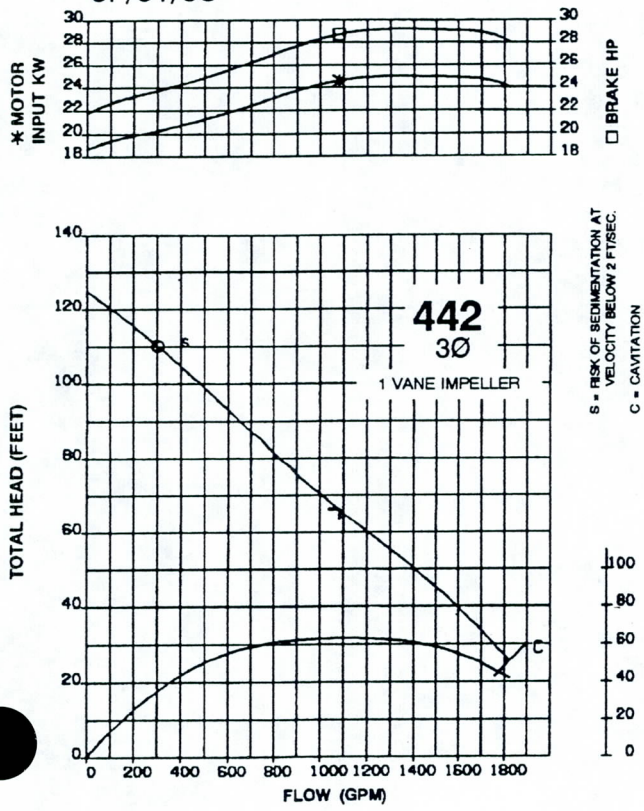
			Road H	Road G-1	Road A-1
1st Pump On	Q (desirable)	gpm	1661	1735	1656
	Max Head (TDH)	ft	43	45	40
Use #C-3170	Min Head (TDH-5)	ft	38	40	35
Pump w/ 443	Min Q Pumped	gpm	1425	1390	1475
impeller	Max Q Pumped	gpm	1510	1475	1565
2nd Pump On	Max Head (TDH-7)	ft	36	38	33
	Min Head (TDH-9.5)	ft	33.5	35.5	30.5
	Min Q Pumped	gpm	1550	1510	1600
	Max Q Pumped	gpm	1590	1560	1635

For Ponding Calcs:

1 Pump On, Q/Pump =	gpm	1500	1450	1550
2 " " , Q/Pump =	gpm	1575	1550	1625

SECTION	PAGE	WASTEWATER	IMPELLER PERFORMANCE CURVES	C-3170
3	1			
SUPERSEDES	ISSUED 6/90			

CP/CT/CS



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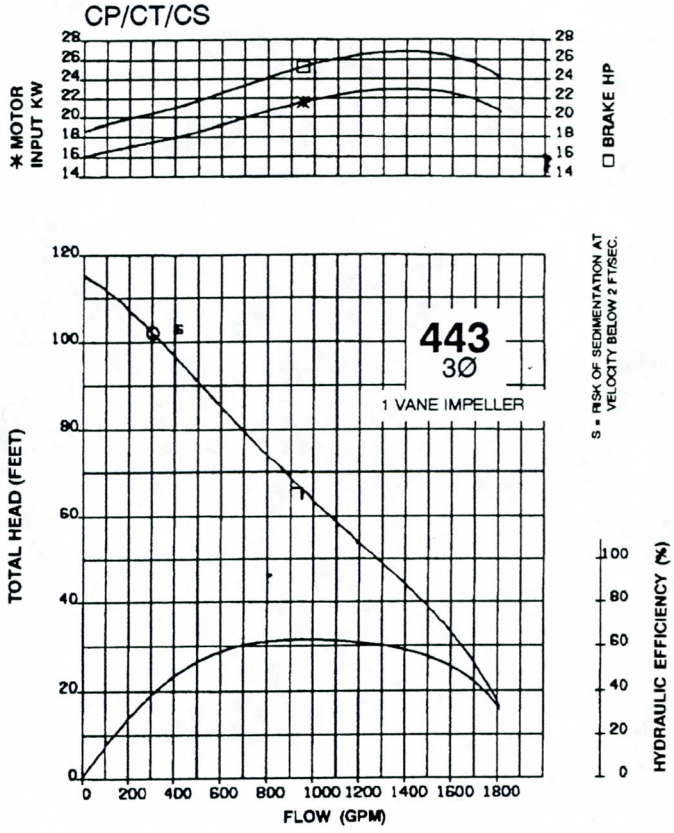

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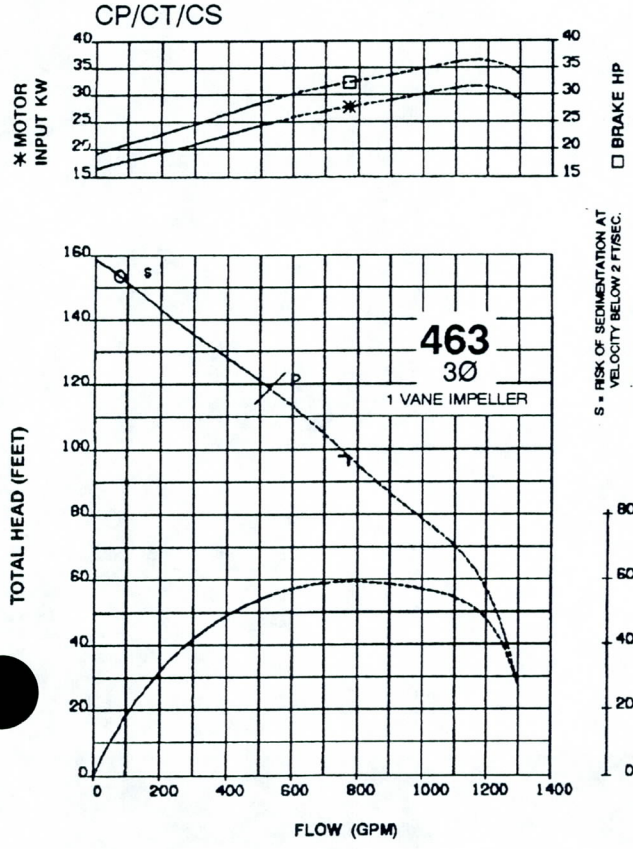

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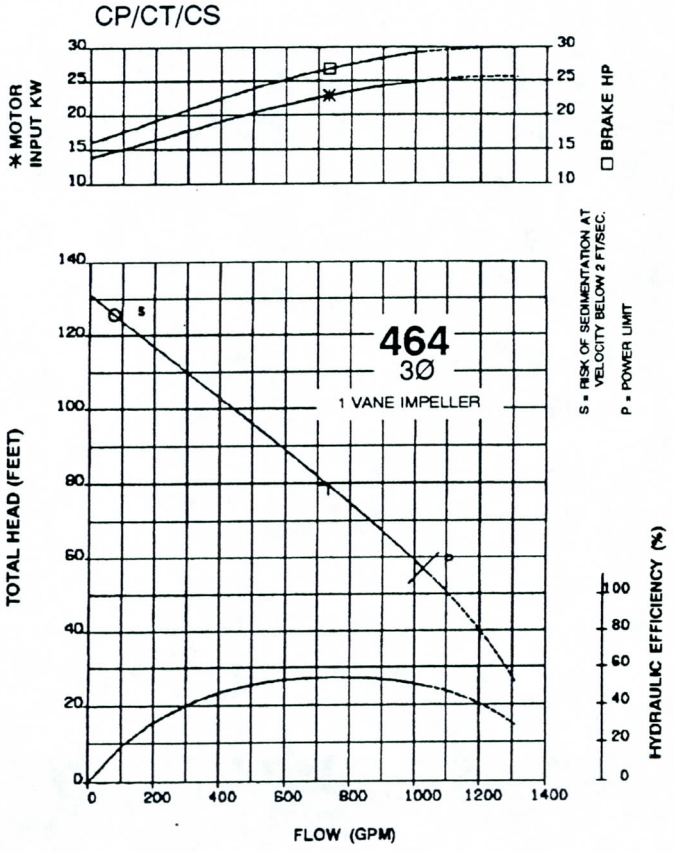

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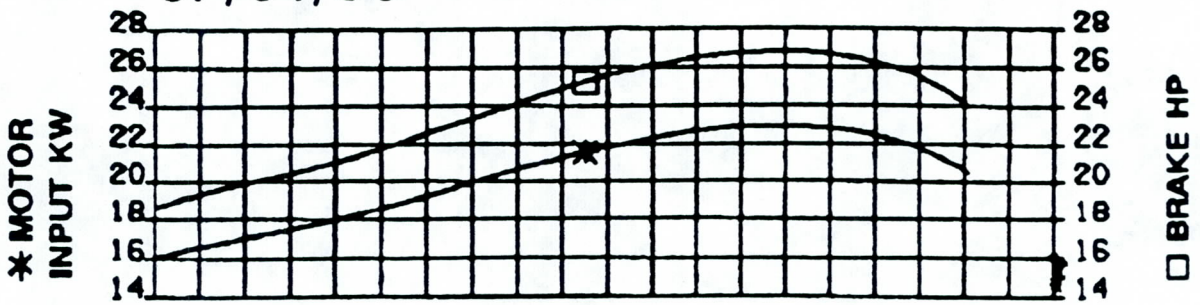
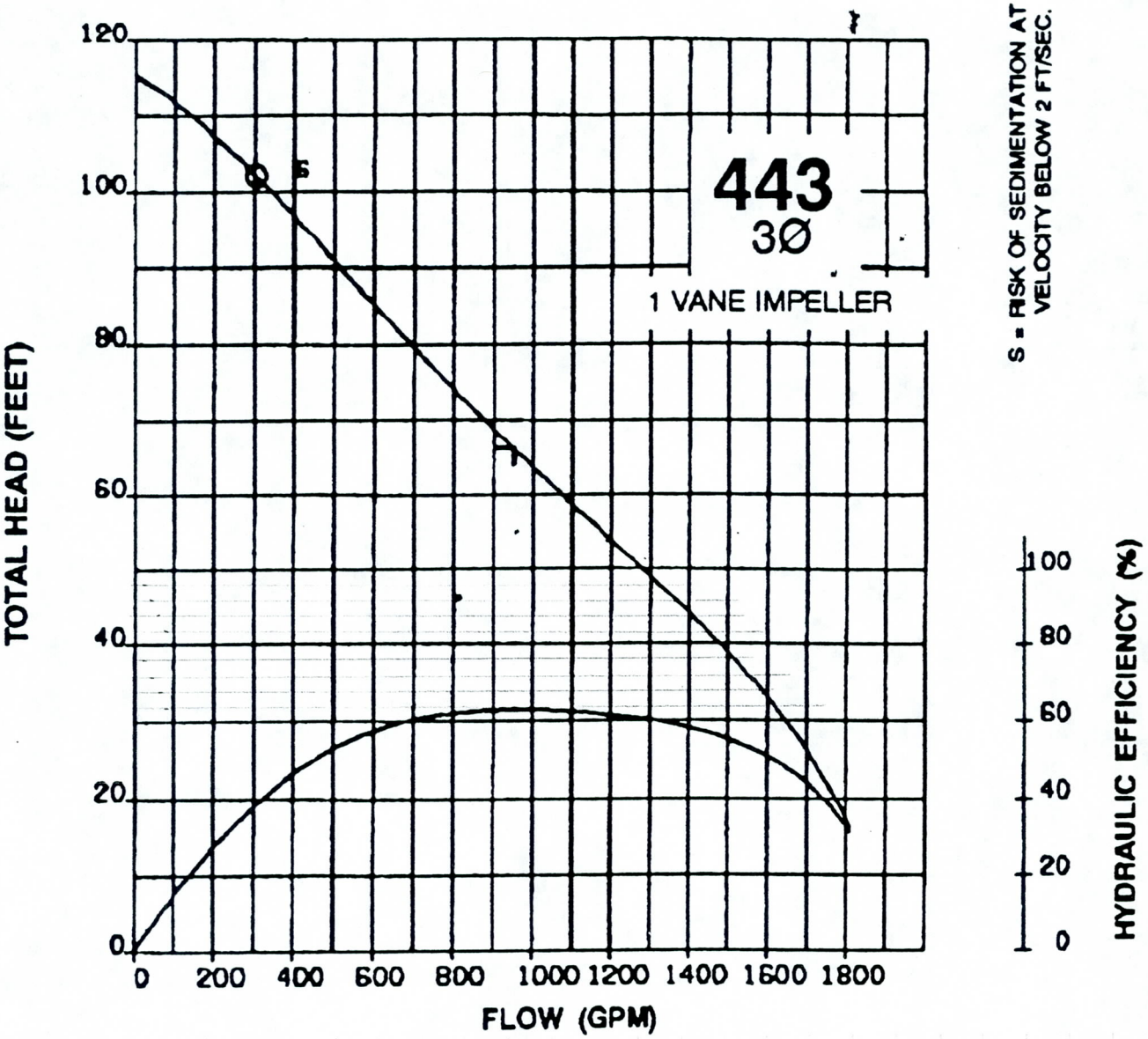




HEAD	Q	HEAD	Q
46 FT	1375 gpm	36 FT	1550 gpm
44	1400	34	1580
42	1450	32	1620
40	1475	30	1640
38	1510		

SVERDRUP

JOB TOYOTA 40477 SHEET NO. 31 OF 53

DATE 8/91

COMPUTATIONS FOR UNDERPASS DRAIN BY BGW CHKD RJS

STORAGE VOLUME CALCULATIONS

		#1	#2	#3
$V = C\left(\frac{P}{12}\right)A$	C	.53	.52	.55
	AREA = (ACRES)	2.29	2.44	2.20

FOR 10 YR STORM $\Rightarrow P^{2\,HR}_{10\,YR} = 1.8$ IN.

50 YR STORM $\Rightarrow P^{2}_{50} = 2.45$ IN

$V_{10} = (C)\left(\frac{1.8}{12}\right)A$	= (AC-FEET)	.182	.190	.181
$V_{50} = (C)\left(\frac{2.45}{12}\right)A$	= (AC-FT)	.248	.259	.247
$Q_{10} = CiA =$ (PREV SHEET)	(CFS)	7.40	7.73	7.38
$Q_{50} = (C)(8.3)A$	(CFS)	10.07	10.53	10.04

$T_C = 5$ MIN

$T_R = 13.6$ MIN (TABLE 3.2 PIMA FLOOD MAN.)

SEE FOLLOWING SPREED SHEETS FOR SYNTHETIC FLOOD HYDROGRAPH

ASSUMED STORAGE AREA=

SYNTHETIC FLOOD HYDROGRAPH
FOR THE UNDERPASS PUMP STATIONS

UNIT HYDROGRAPH

t/Tr	q/Qp	v/V
0.0	0.000	0.000
0.1	0.025	0.002
0.2	0.087	0.007
0.3	0.160	0.020
0.4	0.243	0.036
0.5	0.346	0.063
0.6	0.451	0.096
0.7	0.576	0.136
0.8	0.738	0.180
0.9	0.887	0.253
1.0	1.000	0.325
1.1	0.924	0.400
1.2	0.839	0.464
1.3	0.756	0.523
1.4	0.678	0.578
1.5	0.604	0.627
1.6	0.545	0.671
1.7	0.482	0.707
1.8	0.424	0.742
1.9	0.372	0.773
2.0	0.323	0.799
2.2	0.241	0.841
2.4	0.179	0.875
2.6	0.136	0.900
2.8	0.102	0.917
3.0	0.078	0.932
3.4	0.049	0.953
3.8	0.030	0.965
4.2	0.020	0.973
4.6	0.012	0.979
5.0	0.008	0.983
7.0	0.000	1.000

SYNTHETIC FLOOD HYDROGRAPH
FOR THE ACCESS ROAD "H" UNDERPASS

FOR 10 YEAR STORM:

V= 0.182 ACRE-FT
Q= 7.40 CFS
Tr= 13.600 MIN.

t MIN.	q CFS	Σ v (ACRE-FT)	Σ v (GALLONS)	PUMP RATE (GPM)	Σ VOLUME PUMPED (GALLONS)	STORAGE (GALLONS)	STANDING WATER (GALLONS)
0.00	0.000	0.000	0			0	0
1.36	0.185	0.000	119		0	119	0
2.72	0.644	0.001	415		0	415	0
4.08	1.184	0.004	1186		0	1186	0
5.44	1.798	0.007	2135	1500	2040	95	0
6.80	2.560	0.011	3736	1500	3736	0	0
8.16	3.337	0.017	5693	1500	5693	0	0
9.52	4.262	0.025	8065	1500	7733	332	0
10.88	5.461	0.033	10674	1500	9773	901	0
12.24	6.564	0.046	15003	3150	14057	946	0
13.60	7.400	0.059	19273	3150	18341	932	0
14.96	6.838	0.073	23720	3150	22625	1095	0
16.32	6.209	0.084	27516	3150	26909	607	0
17.68	5.594	0.095	31014	3150	31014	0	0
19.04	5.017	0.105	34276	1500	33054	1222	0
20.40	4.470	0.114	37182	1500	35094	2087	0
21.76	4.033	0.122	39791	1500	37134	2657	0
23.12	3.567	0.129	41926	1500	39174	2751	0
24.48	3.138	0.135	44001	1500	41214	2787	0
25.84	2.753	0.141	45840	1500	43254	2585	0
27.20	2.390	0.145	47381	1500	45294	2087	0
29.92	1.783	0.153	49872	1500	49374	498	0
32.64	1.325	0.159	51888	1500	51888	0	0
35.36	1.006	0.164	53371	0	51888	1483	0
38.08	0.755	0.167	54379	1500	54379	0	0
40.80	0.577	0.170	55268	0	54379	890	0
46.24	0.363	0.173	56514	1500	56514	0	0
51.68	0.222	0.176	57225	0	56514	712	0
57.12	0.148	0.177	57700	0	56514	1186	0
62.56	0.089	0.178	58056	0	56514	1542	0
68.00	0.059	0.179	58293	1500	58293	0	0
95.20	0.000	0.182	59301	1500	59301	0	0

SYNTHETIC FLOOD HYDROGRAPH
FOR THE ACCESS ROAD "H" UNDERPASS

FOR 50 YEAR STORM:

V= 0.248 ACRE-FEET
Q= 10.07 CFS
Tr= 13.600.MIN.

t MIN.	q CFS	Σ v (ACRE-FT)	Σ v (GALLONS)	PUMP RATE (GPM)	Σ VOLUME PUMPED (GALLONS)	STORAGE (GALLONS)	STANDING WATER (GALLONS)
0.00	0.000	0.000	0	0	0	0	0
1.36	0.252	0.000	162	0	0	162	0
2.72	0.876	0.002	566	0	0	566	0
4.08	1.611	0.005	1616	0	0	1616	0
5.44	2.447	0.009	2909	1500	2040	869	0
6.80	3.484	0.016	5091	1500	4080	1011	0
8.16	4.542	0.024	7757	1500	6120	1637	0
9.52	5.800	0.034	10990	3150	10404	586	0
10.88	7.432	0.045	14545	3150	14545	0	0
12.24	8.932	0.063	20444	3150	18829	1615	0
13.60	10.070	0.081	26262	3150	23113	3149	0
14.96	9.305	0.099	32322	3150	27397	4925	1005
16.32	8.449	0.115	37494	3150	31681	5813	1893
17.68	7.613	0.130	42261	3150	35965	6296	2376
19.04	6.827	0.143	46706	3150	40249	6457	2537
20.40	6.082	0.155	50665	3150	44533	6132	2212
21.76	5.488	0.166	54221	3150	48817	5404	1484
23.12	4.854	0.175	57130	3150	53101	4029	109
24.48	4.270	0.184	59958	3150	57385	2573	0
25.84	3.746	0.192	62463	3150	61669	794	0
27.20	3.253	0.198	64564	3150	64564	0	0
29.92	2.427	0.209	67957	1500	67957	0	0
32.64	1.803	0.217	70705	1500	70705	0	0
35.36	1.370	0.223	72725	1500	72725	0	0
38.08	1.027	0.227	74099	0	72725	1374	0
40.80	0.785	0.231	75311	1500	75311	0	0
46.24	0.493	0.236	77008	1500	77008	0	0
51.68	0.302	0.239	77977	0	77008	970	0
57.12	0.201	0.241	78624	0	77008	1616	0
62.56	0.121	0.243	79109	1500	79109	0	0
68.00	0.081	0.244	79432	0	79109	323	0
95.20	0.000	0.248	80806	1500	80806	0	0

SYNTHETIC FLOOD HYDROGRAPH
FOR THE ACCESS ROAD "G-1" UNDERPASS

FOR 10 YEAR STORM:

V= 0.190 ACRE-FT
Q= 7.73 CFS
Tr= 13.600 MIN.

t MIN.	q CFS	Σ v (ACRE-FT)	Σ v (GALLONS)	PUMP RATE (GPM)	Σ VOLUME PUMPED (GALLONS)	STORAGE (GALLONS)	STANDING WATER (GALLONS)
0.00	0.000	0.000	0			0	0
1.36	0.193	0.000	124		0	124	0
2.72	0.673	0.001	433		0	433	0
4.08	1.237	0.004	1238		0	1238	0
5.44	1.878	0.007	2229	1450	1972	257	0
6.80	2.675	0.012	3900	1450	3900	0	0
8.16	3.486	0.018	5943	1450	5872	71	0
9.52	4.452	0.026	8419	1450	7844	575	0
10.88	5.705	0.034	11143	1450	9816	1327	0
12.24	6.857	0.048	15663	3100	14032	1630	0
13.60	7.730	0.062	20120	3100	18248	1872	0
14.96	7.143	0.076	24763	3100	22464	2299	0
16.32	6.485	0.088	28725	3100	26680	2045	0
17.68	5.844	0.099	32378	3100	30896	1481	0
19.04	5.241	0.110	35783	3100	35112	670	0
20.40	4.669	0.119	38816	3100	38816	0	0
21.76	4.213	0.127	41540	1450	40788	752	0
23.12	3.726	0.134	43769	1450	42760	1009	0
24.48	3.278	0.141	45935	1450	44732	1203	0
25.84	2.876	0.147	47854	1450	46704	1150	0
27.20	2.497	0.152	49464	1450	48676	788	0
29.92	1.863	0.160	52064	1450	52064	0	0
32.64	1.384	0.166	54169	1450	54169	0	0
35.36	1.051	0.171	55717	0	54169	1548	0
38.08	0.788	0.174	56769	1450	56769	0	0
40.80	0.603	0.177	57698	0	56769	929	0
46.24	0.379	0.181	58998	1450	58998	0	0
51.68	0.232	0.183	59741	0	58998	743	0
57.12	0.155	0.185	60236	0	58998	1238	0
62.56	0.093	0.186	60607	1450	60607	0	0
68.00	0.062	0.187	60855	0	60607	248	0
95.20	0.000	0.190	61907	1450	61907	0	0

SYNTHETIC FLOOD HYDROGRAPH
FOR THE ACCESS ROAD "G-1" UNDERPASS

FOR 50 YEAR STORM:

V= 0.259 ACRE-FEET
Q= 10.53 CFS
Tr= 13.600 MIN.

t MIN.	q CFS	Σ v (ACRE-FT)	Σ v (GALLONS)	PUMP RATE (GPM)	Σ VOLUME PUMPED (GALLONS)	STORAGE (GALLONS)	STANDING WATER (GALLONS)
0.00	0.000	0.000	0	0	0	0	0
1.36	0.263	0.001	169	0	0	169	0
2.72	0.916	0.002	591	0	0	591	0
4.08	1.685	0.005	1688	0	0	1688	0
5.44	2.559	0.009	3038	1450	1972	1066	0
6.80	3.643	0.016	5317	1450	3944	1373	0
8.16	4.749	0.025	8101	1450	5916	2185	0
9.52	6.065	0.035	11477	3100	10132	1345	0
10.88	7.771	0.047	15190	3100	14348	842	0
12.24	9.340	0.066	21351	3100	18564	2787	0
13.60	10.530	0.084	27427	3100	22780	4647	727
14.96	9.730	0.104	33756	3100	26996	6760	2840
16.32	8.835	0.120	39157	3100	31212	7945	4025
17.68	7.961	0.135	44136	3100	35428	8708	4788
19.04	7.139	0.150	48777	3100	39644	9133	5213
20.40	6.360	0.162	52912	3100	43860	9052	5132
21.76	5.739	0.174	56625	3100	48076	8549	4629
23.12	5.075	0.183	59663	3100	52292	7371	3451
24.48	4.465	0.192	62617	3100	56508	6109	2189
25.84	3.917	0.200	65233	3100	60724	4509	589
27.20	3.401	0.207	67427	3100	64940	2487	0
29.92	2.538	0.218	70972	1450	68884	2088	0
32.64	1.885	0.227	73841	1450	72828	1013	0
35.36	1.432	0.233	75951	1450	75951	0	0
38.08	1.074	0.238	77385	0	75951	1435	0
40.80	0.821	0.241	78651	1450	78651	0	0
46.24	0.516	0.247	80423	0	78651	1772	0
51.68	0.316	0.250	81436	1450	81436	0	0
57.12	0.211	0.252	82111	0	81436	675	0
62.56	0.126	0.254	82617	0	81436	1181	0
68.00	0.084	0.255	82955	0	81436	1519	0
95.20	0.000	0.259	84390	1450	84390	0	0

SYNTHETIC FLOOD HYDROGRAPH
FOR THE ACCESS ROAD "A-1" UNDERPASS

FOR 50 YEAR STORM:

V= 0.247 ACRE-FEET
Q= 10.04 CFS
Tr= 13.600 MIN.

t MIN.	q CFS	Σ v (ACRE-FT)	Σ v (GALLONS)	PUMP RATE (GPM)	Σ VOLUME PUMPED (GALLONS)	STORAGE (GALLONS)	STANDING WATER (GALLONS)
0.00	0.000	0.000	0	0	0	0	0
1.36	0.251	0.000	161	0	0	161	0
2.72	0.873	0.002	563	0	0	563	0
4.08	1.606	0.005	1610	0	0	1610	0
5.44	2.440	0.009	2897	1550	2108	789	0
6.80	3.474	0.016	5070	1550	4216	854	0
8.16	4.528	0.024	7726	1550	6324	1402	0
9.52	5.783	0.034	10945	1550	8432	2513	0
10.88	7.410	0.044	14486	3250	12852	1634	0
12.24	8.905	0.062	20361	3250	17272	3089	0
13.60	10.040	0.080	26156	3250	21692	4464	544
14.96	9.277	0.099	32192	3250	26112	6080	2160
16.32	8.424	0.115	37343	3250	30532	6811	2891
17.68	7.590	0.129	42091	3250	34952	7139	3219
19.04	6.807	0.143	46517	3250	39372	7145	3225
20.40	6.064	0.155	50461	3250	43792	6669	2749
21.76	5.472	0.166	54002	3250	48212	5790	1870
23.12	4.839	0.175	56899	3250	52632	4267	347
24.48	4.257	0.183	59716	3250	57052	2664	0
25.84	3.735	0.191	62211	3250	61472	739	0
27.20	3.243	0.197	64303	3250	64303	0	0
29.92	2.420	0.208	67683	1550	67683	0	0
32.64	1.797	0.216	70420	1550	70420	0	0
35.36	1.365	0.222	72432	1550	72432	0	0
38.08	1.024	0.226	73800	0	72432	1368	0
40.80	0.783	0.230	75007	1550	75007	0	0
46.24	0.492	0.235	76697	0	75007	1690	0
51.68	0.301	0.238	77663	1550	77663	0	0
57.12	0.201	0.240	78307	0	77663	644	0
62.56	0.120	0.242	78790	0	77663	1127	0
68.00	0.080	0.243	79112	0	77663	1449	0
95.20	0.000	0.247	80480	1550	80480	0	0

SYNTHETIC FLOOD HYDROGRAPH
FOR THE ACCESS ROAD "A-1" UNDERPASS

FOR 10 YEAR STORM:

V= 0.181 ACRE-FT
Q= 7.38 CFS
Tr= 13.600 MIN.

t MIN.	q CFS	Σ v (ACRE-FT)	Σ v (GALLONS)	PUMP RATE (GPM)	Σ VOLUME PUMPED (GALLONS)	STORAGE (GALLONS)	STANDING WATER (GALLONS)
0.00	0.000	0.000	0			0	0
1.36	0.185	0.000	118		0	118	0
2.72	0.642	0.001	413		0	413	0
4.08	1.181	0.004	1180		0	1180	0
5.44	1.793	0.007	2123	1550	2108	15	0
6.80	2.553	0.011	3715	0	2108	1607	0
8.16	3.328	0.017	5662	1550	4216	1446	0
9.52	4.251	0.025	8021	1550	6324	1697	0
10.88	5.446	0.033	10616	1550	8432	2184	0
12.24	6.546	0.046	14921	3250	12852	2069	0
13.60	7.380	0.059	19167	3250	17272	1895	0
14.96	6.819	0.072	23590	3250	21692	1898	0
16.32	6.192	0.084	27364	3250	26112	1252	0
17.68	5.579	0.095	30844	3250	30532	312	0
19.04	5.004	0.105	34088	3250	34088	0	0
20.40	4.458	0.113	36977	1550	36196	782	0
21.76	4.022	0.121	39572	1550	38304	1269	0
23.12	3.557	0.128	41695	1550	40412	1284	0
24.48	3.129	0.134	43759	1550	42520	1240	0
25.84	2.745	0.140	45588	1550	44628	960	0
27.20	2.384	0.145	47121	1550	46736	385	0
29.92	1.779	0.152	49598	1550	49598	0	0
32.64	1.321	0.158	51603	1550	51603	0	0
35.36	1.004	0.163	53078	0	51603	1474	0
38.08	0.753	0.166	54080	1550	54080	0	0
40.80	0.576	0.169	54965	0	54080	885	0
46.24	0.362	0.172	56203	1550	56203	0	0
51.68	0.221	0.175	56911	0	56203	708	0
57.12	0.148	0.176	57383	0	56203	1180	0
62.56	0.089	0.177	57737	0	56203	1533	0
68.00	0.059	0.178	57972	0	56203	1769	0
95.20	0.000	0.181	58975	1450	58975	0	0

DTA

CALCULATION OF DEPTH FOR UNDERPASS NO. 2

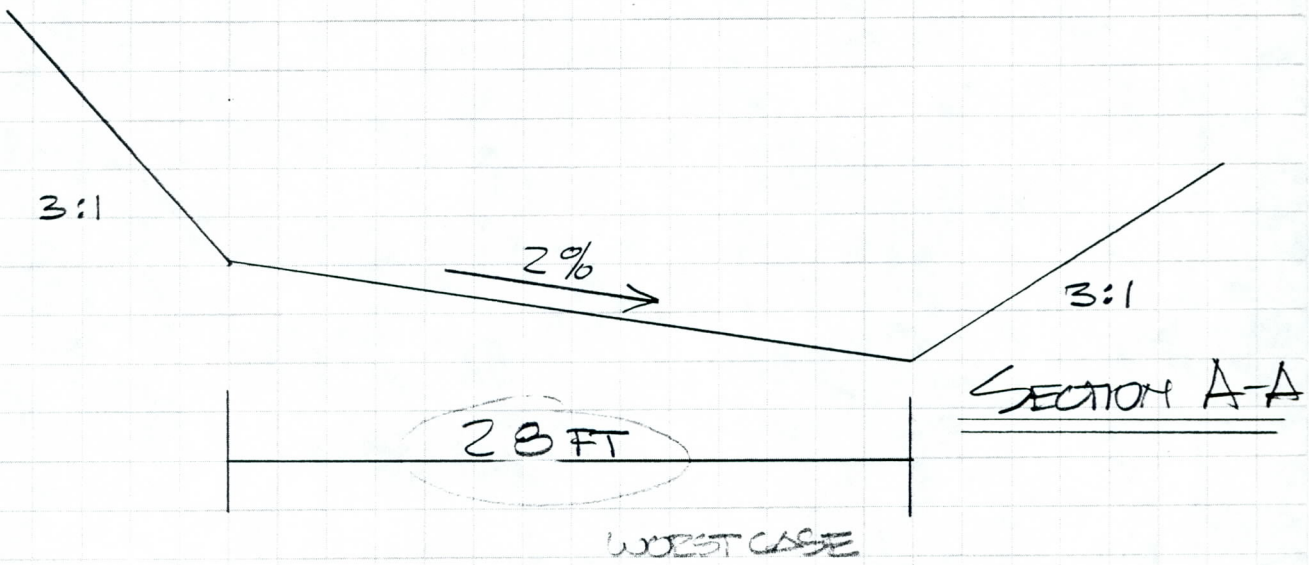
STATION	ELEVATION (ROAD CENTER)			DIFFERENCE FROM SUMP
9525	1722.70	R =	2.50	5.00
9535	1722.21	BVC STA:	9525.00	4.51
9545	1721.75	BVC ELEV	1722.70	4.05
9555	1721.31	G1 =	-5.00	3.61
9565	1720.90			3.20
9575	1720.51			2.81
9585	1720.15			2.45
9595	1719.81			2.11
9605	1719.50			1.80
9615	1719.21			1.51
9625	1718.95			1.25
9635	1718.71			1.01
9645	1718.50			0.80
9655	1718.31			0.61
9665	1718.15			0.45
9675	1718.01			0.31
9685	1717.90			0.20
9695	1717.81			0.11
9705	1717.75			0.05
9715	1717.71			0.01
9725	1717.70 ← SUMP ℄ ELEV.			0.00
9735	1717.71			0.01
9745	1717.75			0.05
9755	1717.81			0.11
9765	1717.90			0.20
9775	1718.01			0.31
9785	1718.15			0.45
9795	1718.31			0.61
9805	1718.50			0.80
9815	1718.71			1.01
9825	1718.95			1.25
9835	1719.21			1.51
9845	1719.50			1.80
9855	1719.81			2.11
9865	1720.15			2.45
9875	1720.51			2.81
9885	1720.90			3.20
9895	1721.31			3.61
9905	1721.75			4.05
9915	1722.21			4.51
9925	1722.70			5.00
9935	1723.21			5.51
9945	1723.75			6.05
9955	1724.31			6.61
9965	1724.90			7.20
9975	1725.51			7.81

TYPICAL ELEVATION DIFFERENCES FOR ALL SUMP CURVES.

SVERDRUP

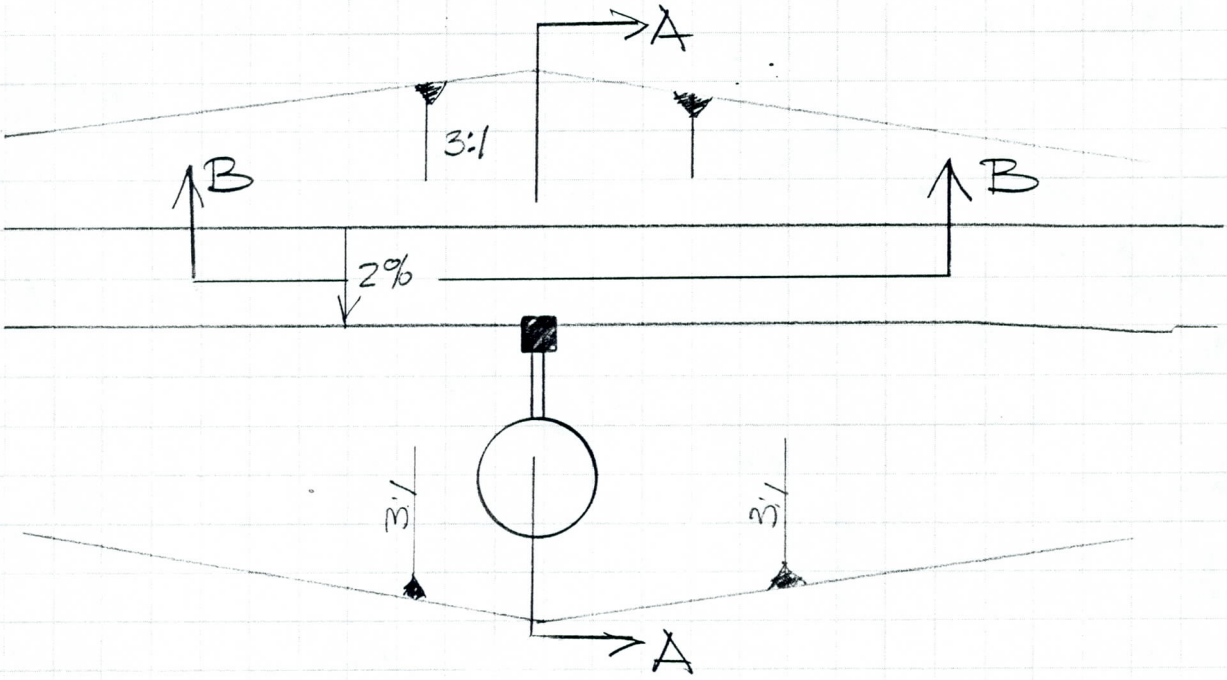
JOB TOYOTA 40477 SHEET NO. 40 OF 53

COMPUTATIONS FOR ACCESS ROAD PONDING. DATE 8/91 BY BSW CHKD RJT



SECTION A-A

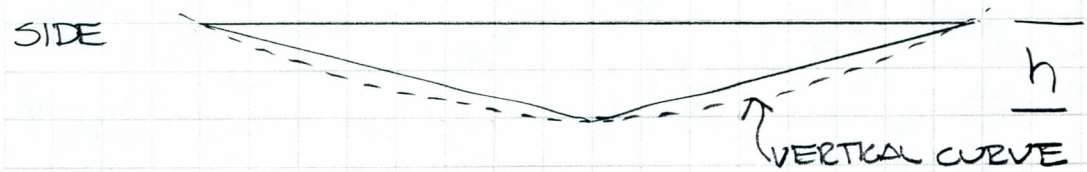
FOR THE 10 YEAR STORM, APPROX 000 GALLONS (ROAD G-1)
" " 50 " " " 5213 " " "

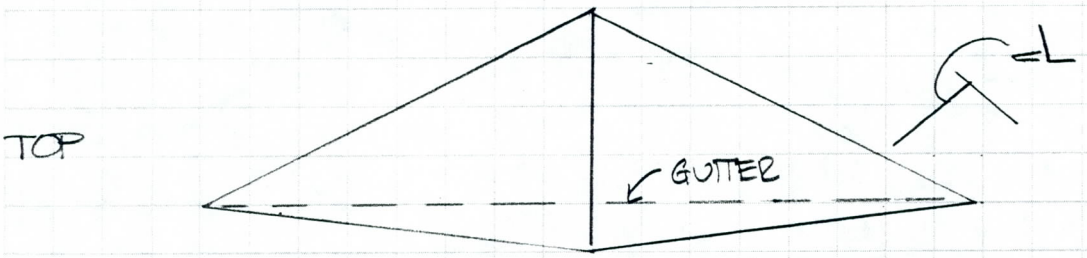


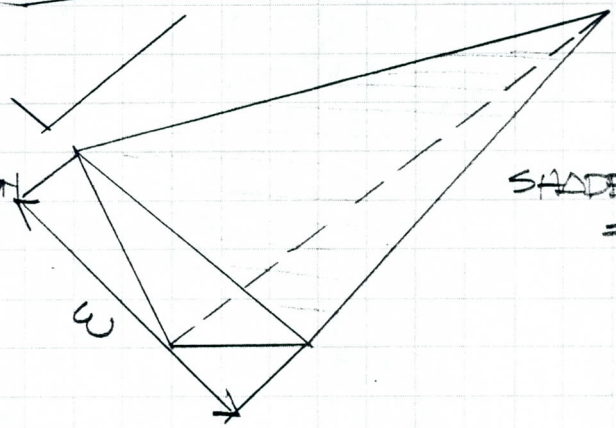
SECTION B-B (FOR CALC. PURPOSES.)

FOR 1/2 PAVEMENT WIDTH COVERED:

Δ FLEV = (12.5 FT)(.02) = .25 FT







VOLUME OF PYRAMID

$$V = \frac{\text{BASE}(h)}{3}$$

FOR 1/2 PAVEMENT COVERED: $h = .25$ FT

$w = 12.5 + .25/.33 = 13.25$

$L = 45$ FT

$$V = \left[\left[\frac{(13.25)(45)}{2}\right]\frac{(.25)}{3}\right]2 = 49.7 \text{ FT}^3 = 372 \text{ GAL.}$$

(AREA Δ OF BASE) (VOL) (2 HALFS.)

SVERDRUP

JOB TOYOTA 40477 SHEET NO. 42 OF 53

COMPUTATIONS FOR UNDERDRAIN DRAIN DATE 8/91

BY BSW CHKD RVT

FOR FULL PAVE. & SHOULDER w/ PONDING

$h = 26.5\ (.02) = .53$

$W = 26.5 + .53/.1333 = 28.1$ FT

$L = 65$ FT

$V = \left[\left[\frac{28.1 \times 65}{2}\right]\frac{.53}{3}\right] 2 = 322.6\ FT^3$

$= 2,413$ GAL.

FOR 1 FT DEPTH @ GUTTER : (WATER ABOVE PAVEMENT SECTION)

$h = 1$ FT

$L = 90$ FT

$W = 26.5 + (1/.1333) + ((1-.53)/.1333) = 30.9$ FT

AREA OF WATER $= 1/2\ (30.9 \times 90) = 1390\ FT^2$

AREA OF WATER @ PAVE $= 1/2\ (65 \times 28.1) = 913\ FT^2$

VOLUME OF WATER ABOVE (.53) $= \frac{(1390+913)}{2}(1-.53)(2) = 1082$

TOTAL VOLUME $1082 + 323\ FT^3 = 1405\ FT^3$

$= 10,509$ GAL.

FOR 2 FT DEPTH @ GUTTER

$h = 2$

$L = 125$ FT

$W = 26.5 + (2/.1333) + ((2-.53)/.1333) = 36.9$ FT

SVERDRUP

JOB TOYOTA 40477 SHEET NO. 43 OF 53

DATE 8/91

COMPUTATIONS FOR UNDERPASS DRAIN BY BSW CHKD RJT

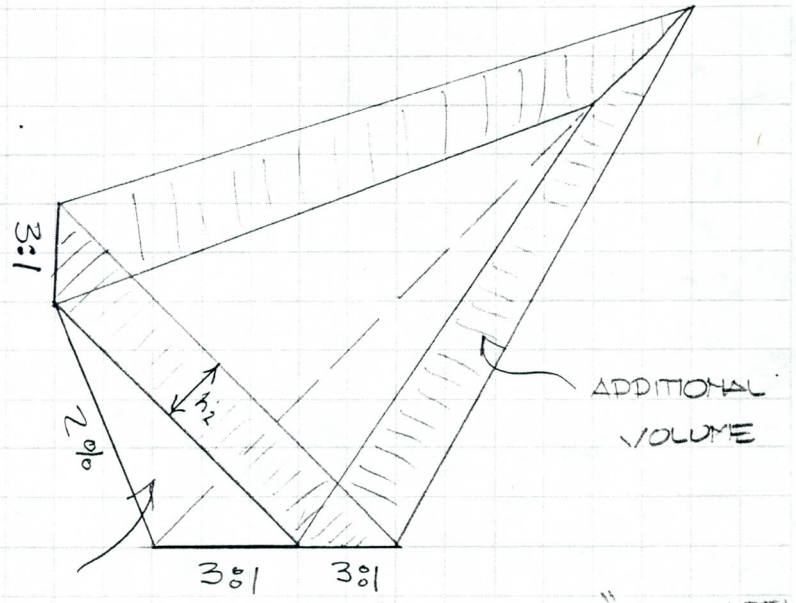
AREA OF WATER SURFACE @ 2.00 FT DEPTH

$= 1/2\,(369 \times 125) = 2,306$

VOLUME OF WATER ABOVE PAVEMENT $= \left[\frac{(2,306 + 913)}{2}\right](2-53)(2) = 4,732\ FT^3$

= TOTAL VOLUME $= 4,732 + 323 = 5,055\ FT^3$

$\triangleq$ 37,811 GAL.



INITIAL VOLUME TO COVER PAVEMENT = "PAVE AREA"

ADDITIONAL VOLUME = AVG. BASE AREA (HEIGHT)

$= \frac{(\text{PAVE. AREA} + \text{NEW TOP AREA})}{2}$ (HEIGHT)

FOR VOLUME, ADD TO PAVE AREA VOLUME.

SVERDRUP

JOB TOYOTA 40477 SHEET NO. 44 OF 53

DATE 8/91

COMPUTATIONS FOR UNDERPASS DRAIN BY BSW CHKD RTT

FOR ACCESS ROADS 'H' & 'G', MIN 8 FT "DRY"

FOR TRAVEL (22.5 FT − 8 = 14.5 FT SPREAD)

$h = 14.5(.02) = .29$ FT

$w = 14.5 + (.29/.333) = 15.37$ FT

$L = 50$ FT

$$V = \left(\left(\frac{(15.37)(50)}{2}\right)\frac{.29}{3}\right)2 = 74.29 \text{ FT}^3$$

$= 556$ GAL

FOR ACCESS ROADS 'H' & 'G', THEY WILL BE "FLOODED" FOR THE FOLLOWING PERIODS ("FLOODED" ⇒ LESS THAN 8 FT OF DRY PAVEMENT)

STORM	'H'	G-1	
10 YR	≙ 0 MIN	0 MIN	} TIME "FLOODED"
50 YR	≙ 7 MIN	13 MIN	

FOR ACCESS ROAD 'A-1', SPREAD (28.5 − 8 = 20.5 FT)

$h = 20.5(.02) = .41$

$w = 20.5 + (.41/.333) = 21.73$ FT

$L = 60$ FT

$$V = \left(\left(\frac{(21.73)(60)}{2}\right)\frac{.41}{3}\right)2$$

$= 178 \text{ FT}^3$

$= 1{,}332$ GAL

ACCESS ROAD 'A-1' WILL BE "FLOODED" FOR:

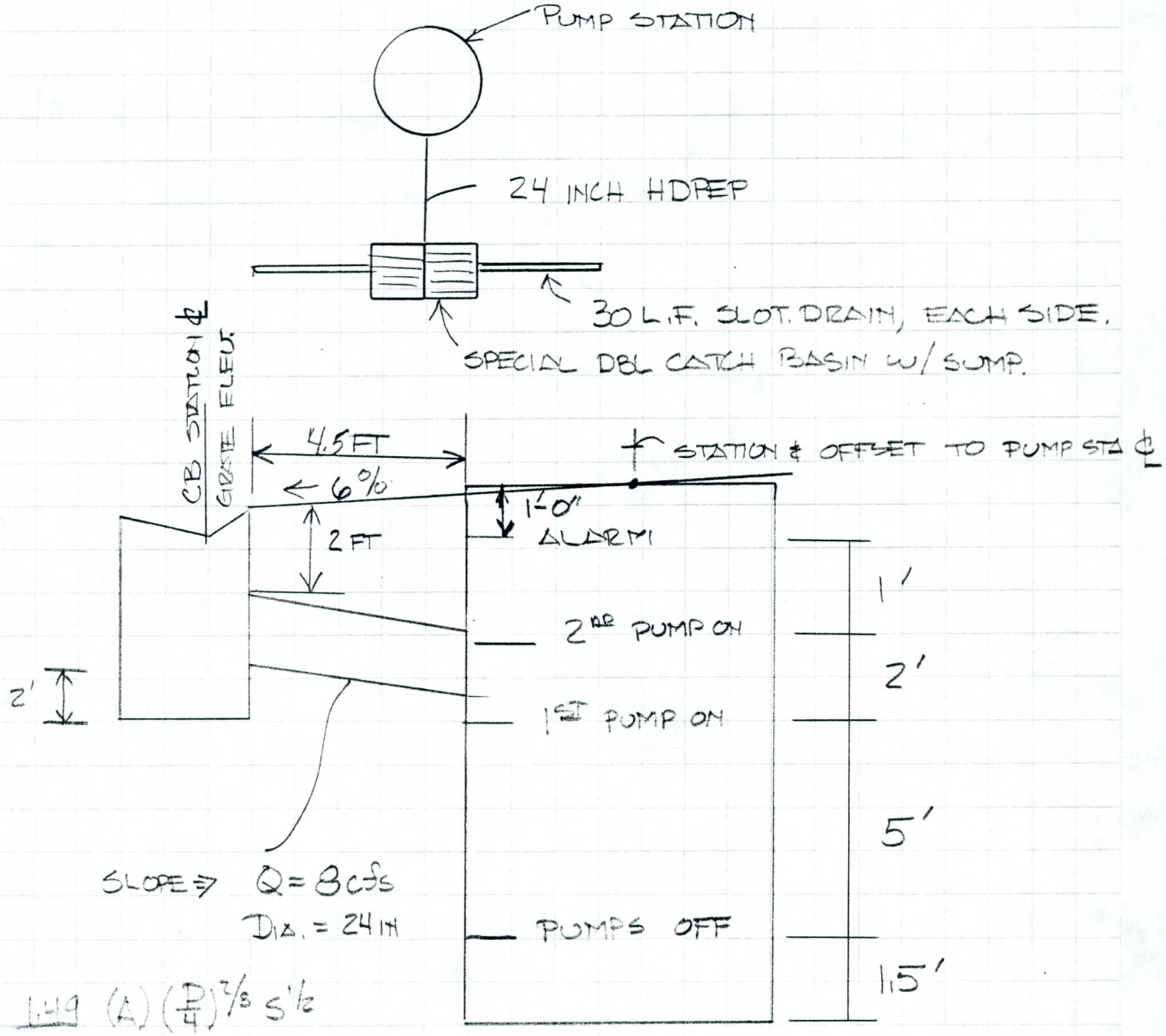
10 YR STORM ≙ 0 MIN, 50 YR STORM ≙ 7 MIN.

SVERDRUP

JOB Toyota 40477 SHEET NO. 45 OF 53

DATE 8/91

COMPUTATIONS FOR Access Road X-Section Profile BY BSW CHKD RVT



$$Q = \frac{1.49}{0.010}(A)\left(\frac{P}{4}\right)^{2/3} S^{1/2}$$

$S = .001$ (MIN.)

SEE "WET WELL SIZING" FOR STEEP GRADE FACILITY FOR SIZING CALCULATIONS.

SUMMARY OF ELEVATIONS

FACILITY	ROAD H	ROAD G-1	ROAD A-1
CATCH BASIN STATION			
STATION	221+50, 12' LT	99+75, 12' LT	29+00, 15' RT
GRATE ELEVATION	1720.98	1717.83	1651.87
24" INV. ELEVATION	1717.48	1714.33	1648.37
FLOOR ELEVATION	1715.48	1712.33	1646.37
LIFT STATION			
STATION	221+50, 23' LT	99+75, 23' LT	29+00, 26' RT
TOP SLAB ELEVATION	1722.02	1718.87	1652.91
FLOOR ELEVATION	1710.02	1706.87	1640.91
PUMPS OFF ELEV.	1711.52	1708.37	1642.41
LEAD PUMP ON ELEV.	1716.52	1713.37	1647.41
LAG PUMP ON ELEV.	1718.52	1715.37	1649.41
ALARM ELEVATION	1719.52	1716.37	1650.41
24" PIPE INV ELEV.	1717.37	1714.22	1648.26

SVERDRUP

JOB TOYOTA 40477 SHEET NO. 46B OF 53

DATE 7/91

COMPUTATIONS FOR PUMP OUTFALL BY BSW CHKD RJT

PLUNGE BASIN DESIGN

MAX PUMP Q $\cong$ 1600 G.P.M/PUMP $\cong$ 7.15 cfs (2 PUMPS)

D = 12 IN

n = 0.10

$$V = \frac{Q}{A} = \frac{7.15}{\frac{\pi}{4}(1)} = 9.1 \text{ FT/SEC}$$

$$\text{FROUD No.} = V / [g D]^{1/2} = (9.1) / [(32.2)(1)]^{1/2} = 1.60$$

FROM FIG II-C-1, HEC 14

$d_{50} \cong 4 \text{ IN} = 0.3\overline{3} \text{ FT}$

Ye = PIPE (BRINE) DEPTH = 1.0 FT

$d_{50}/Ye = 0.3\overline{3}$ FT

FROM FIG XI-2, HEC 14

$h_s/Ye \cong 1.06$ $\quad h_s = 1.06$

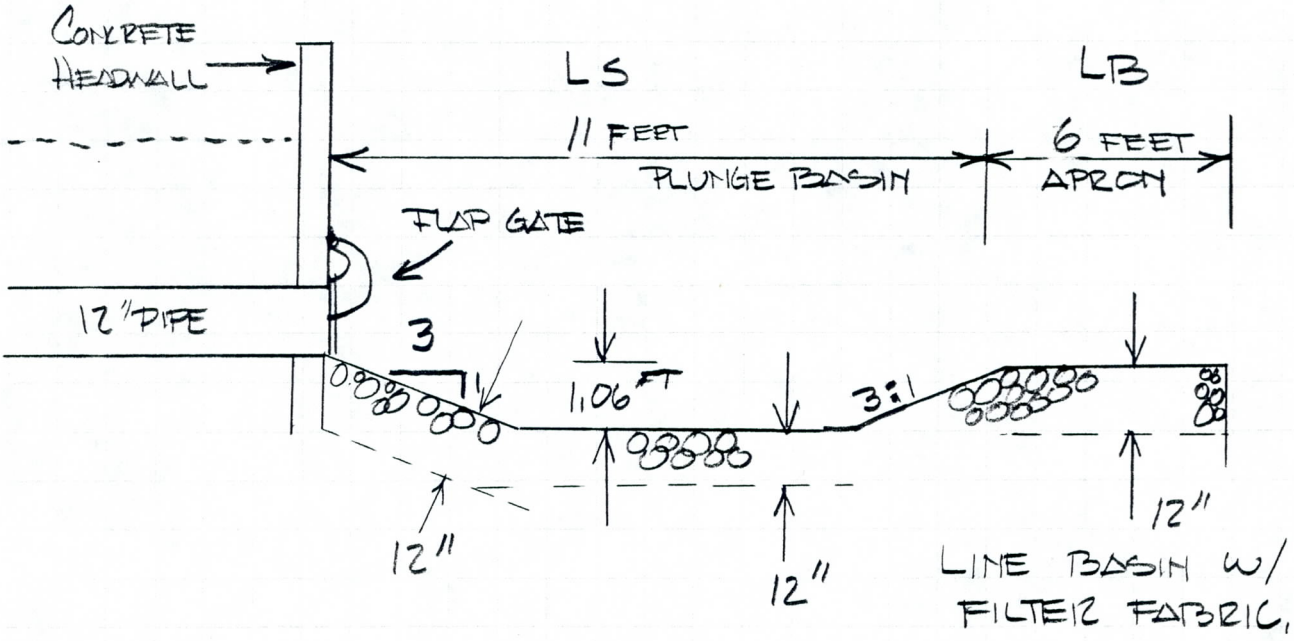
$L_S = 10 h_s = 10.6$ FT USE 11 FT

$L_B = 5 h_s = 5.3$ FT USE 6 FT

SVERDRUP

JOB TOYOTA 40477 SHEET NO. 46C OF 53

COMPUTATIONS FOR PUMP/PLUNGE BASIN DATE 7/91 BY BSW CHKD RVT



FROM HEC 14 DESIGN $d_{50} = 4$ IN

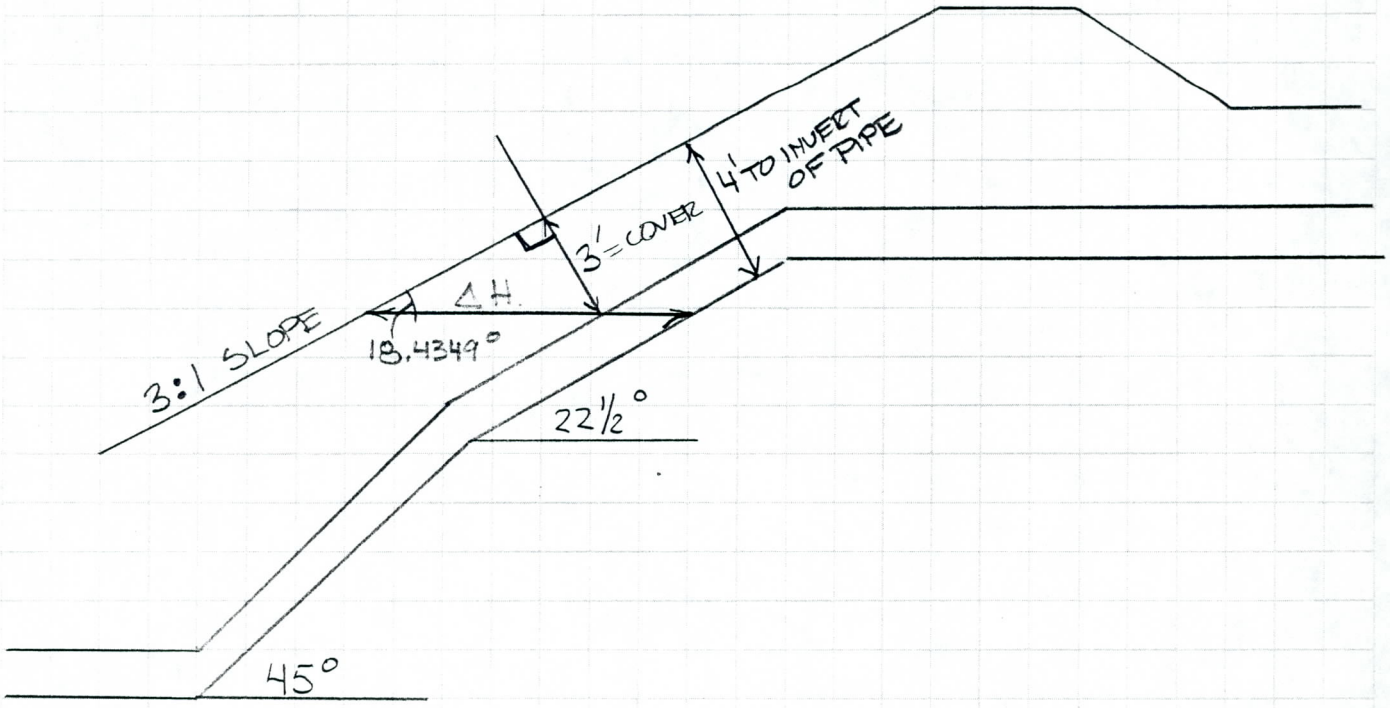
$L_S = 11$ FT

$L_B = 6$ FT

USE 6 IN FOR d_{50}

OUTFALL PIPE

SLOPE COVER



FOR 3FT MIN COVER

Δ Horiz $\Rightarrow$ $\sin\phi = \frac{O}{H} = \frac{4}{\Delta H}$

$\sin(18.4349) = \frac{4}{\Delta H}$

$\Delta H = 4 / \sin(18.4349)$

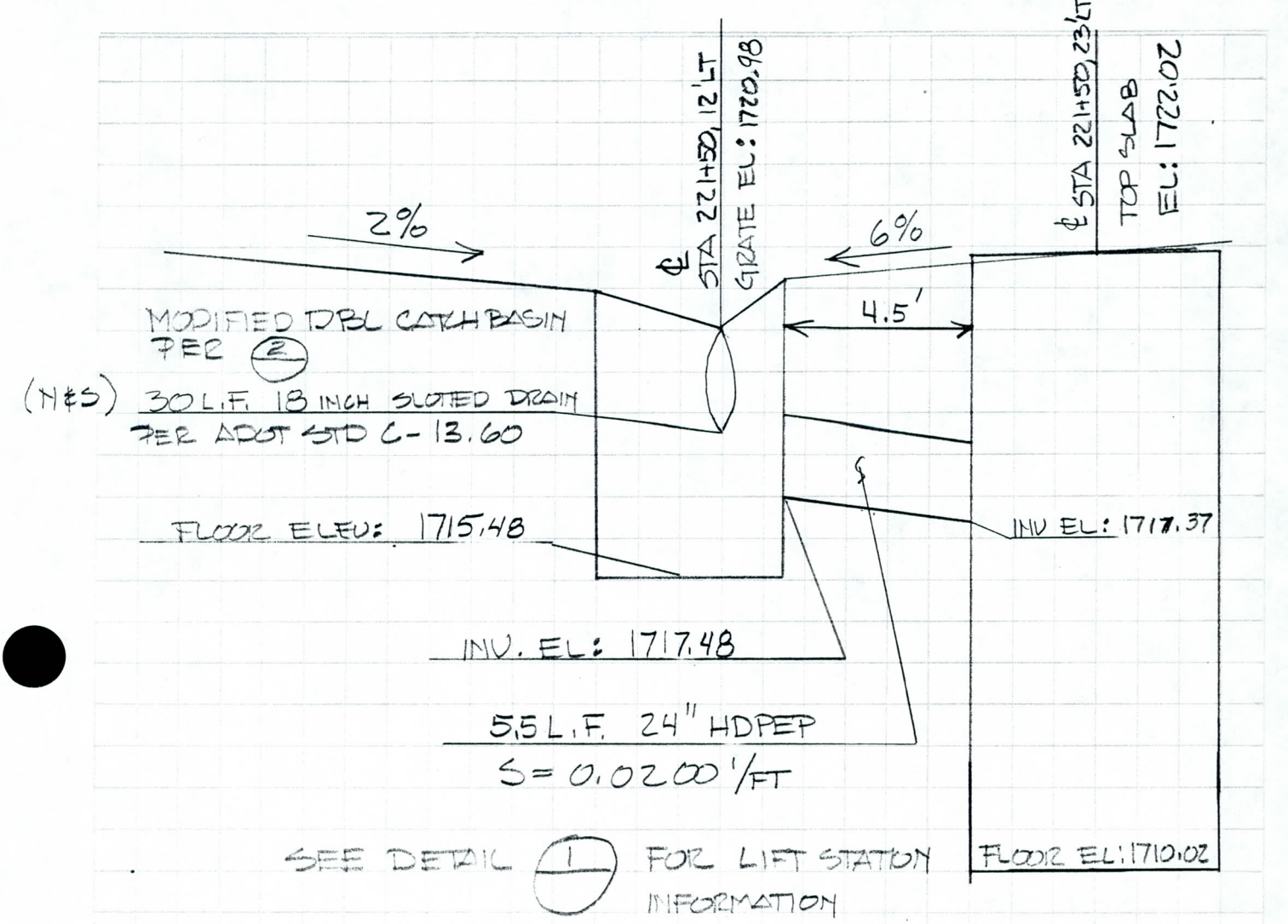
$= 12.65$ FT

SVERDRUP

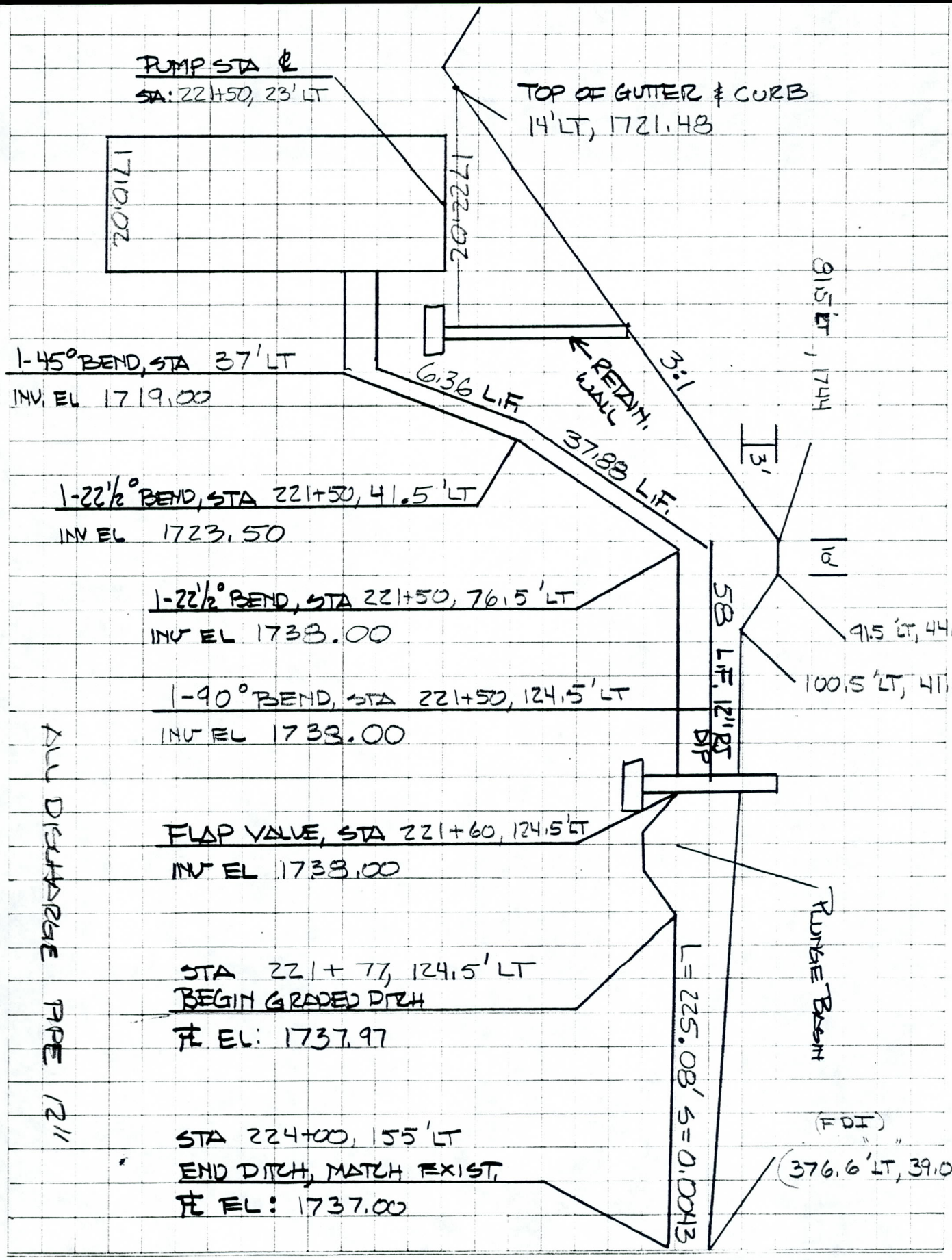
JOB Toyota 40477 SHEET NO. 48 OF 53

COMPUTATIONS FOR Access Road 'H' DATE 8/91

BY BSW CHKD RJT



ACCESS ROAD 'H' DRAINAGE PROFILE



SVERDRUP

JOB Taylor H0477

COMPUTATIONS FOR Access Road 'H' Detail

SHEET NO. 49 OF 53

DATE 8/91

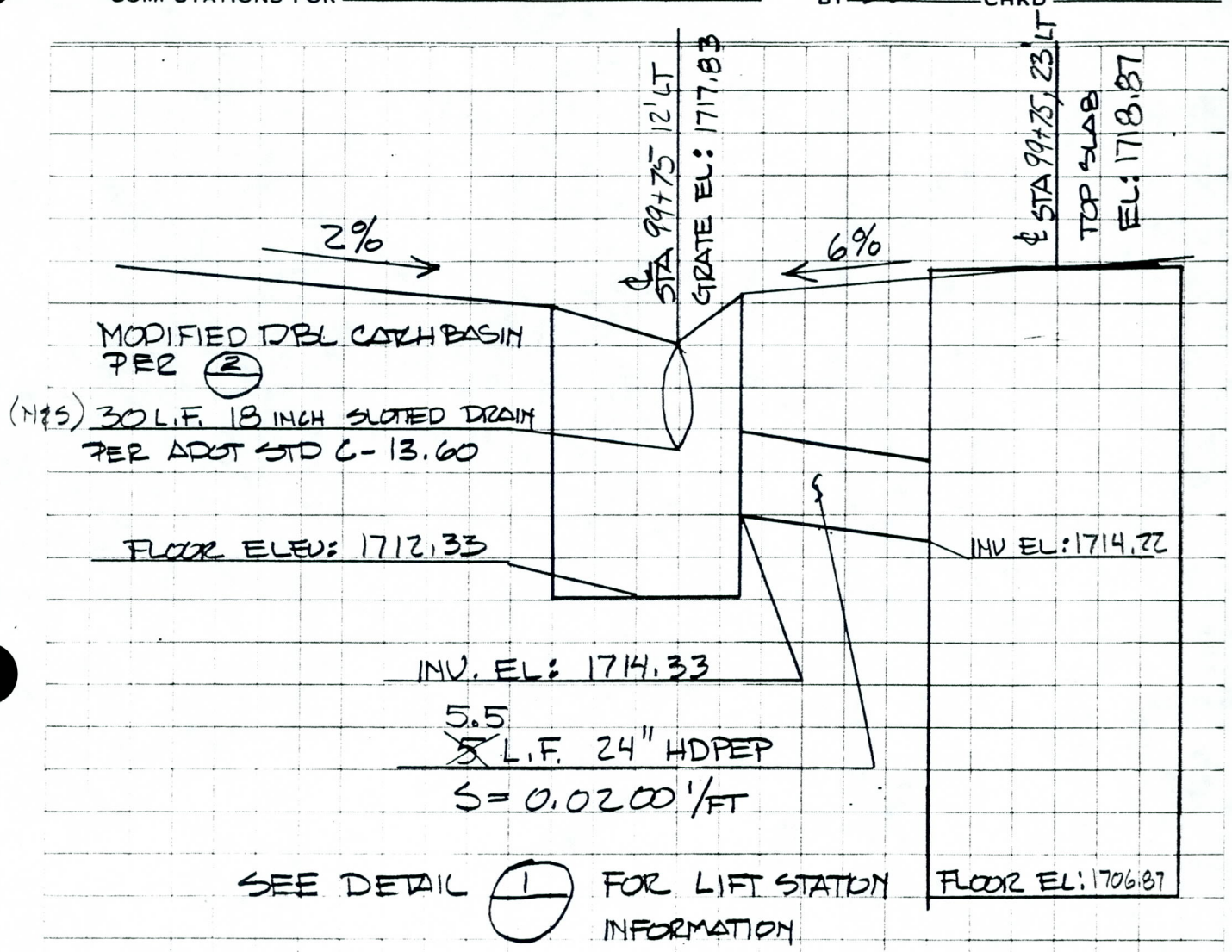
BY BSW CHKD

SVERDRUP

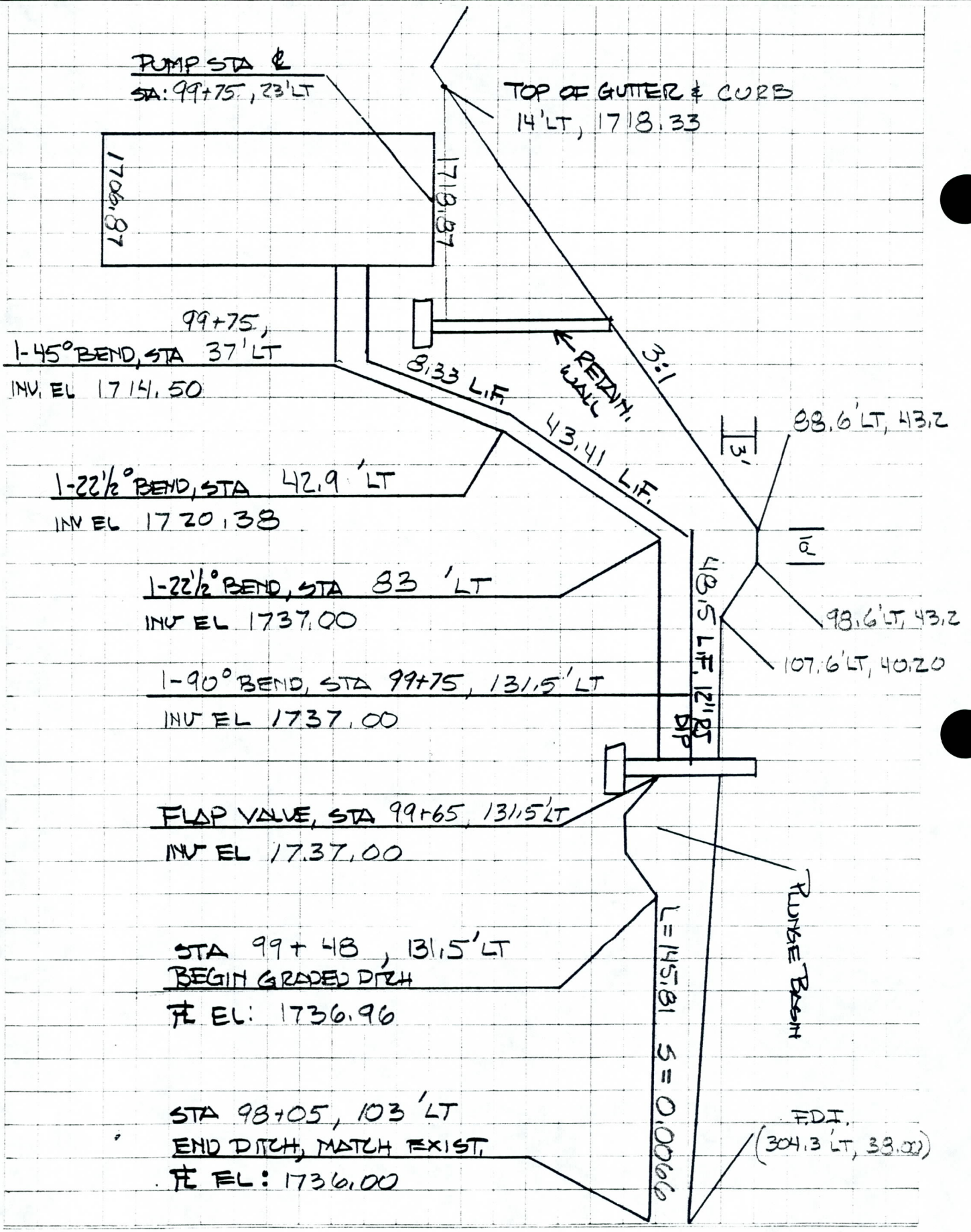
JOB Toyota 40477 SHEET NO. 50 OF 53

COMPUTATIONS FOR Access Road G-1 DATE 8/91

BY BSW CHKD



ACCESS ROAD 'G-1' DRAINAGE PROFILE



SVERDRUP

JOB Topeka 41OH77

COMPUTATIONS FOR Access Road G-1 Outfall

SHEET NO. 51 OF 53

DATE 8/11

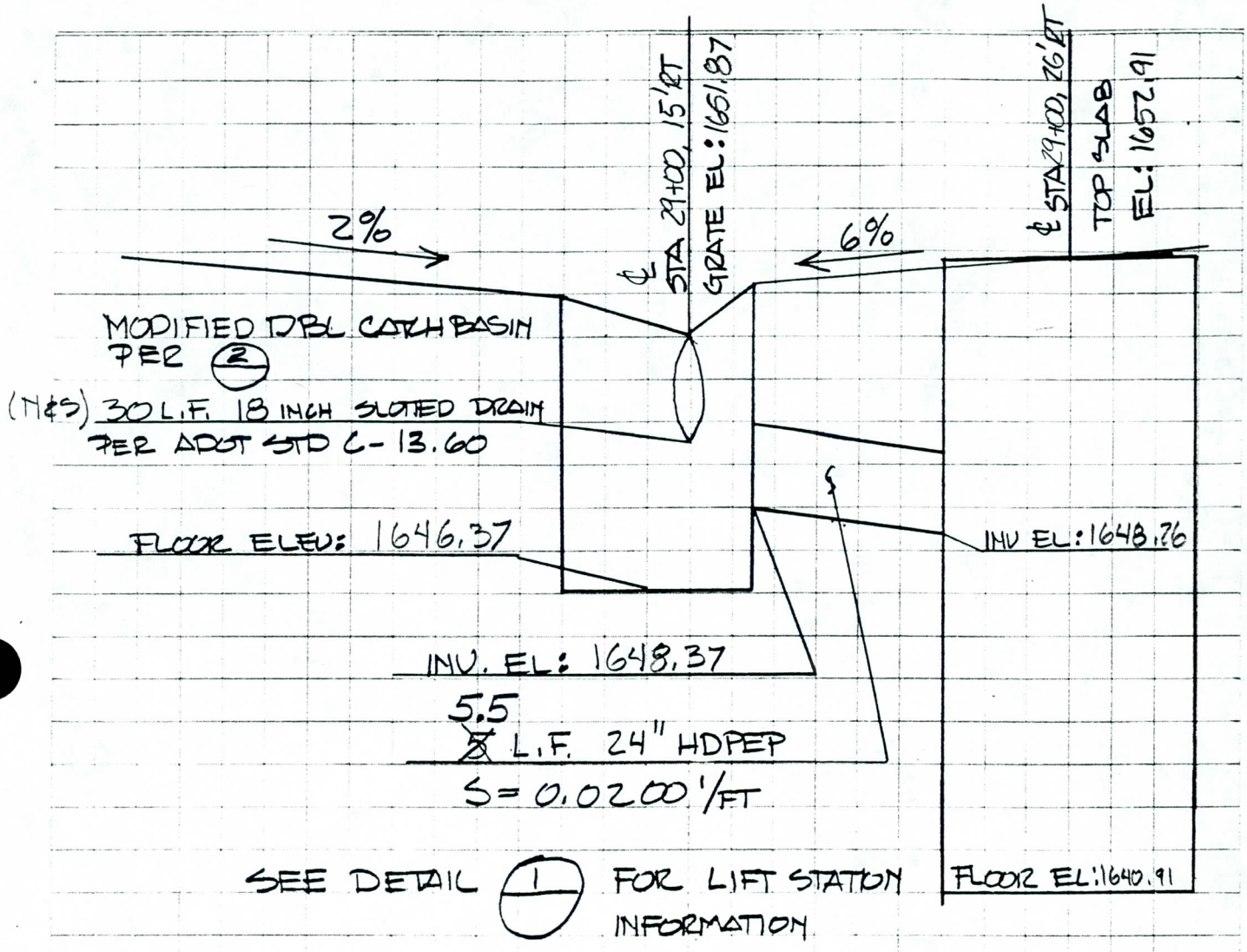
BY [illegible] CHKD

SVERDRUP

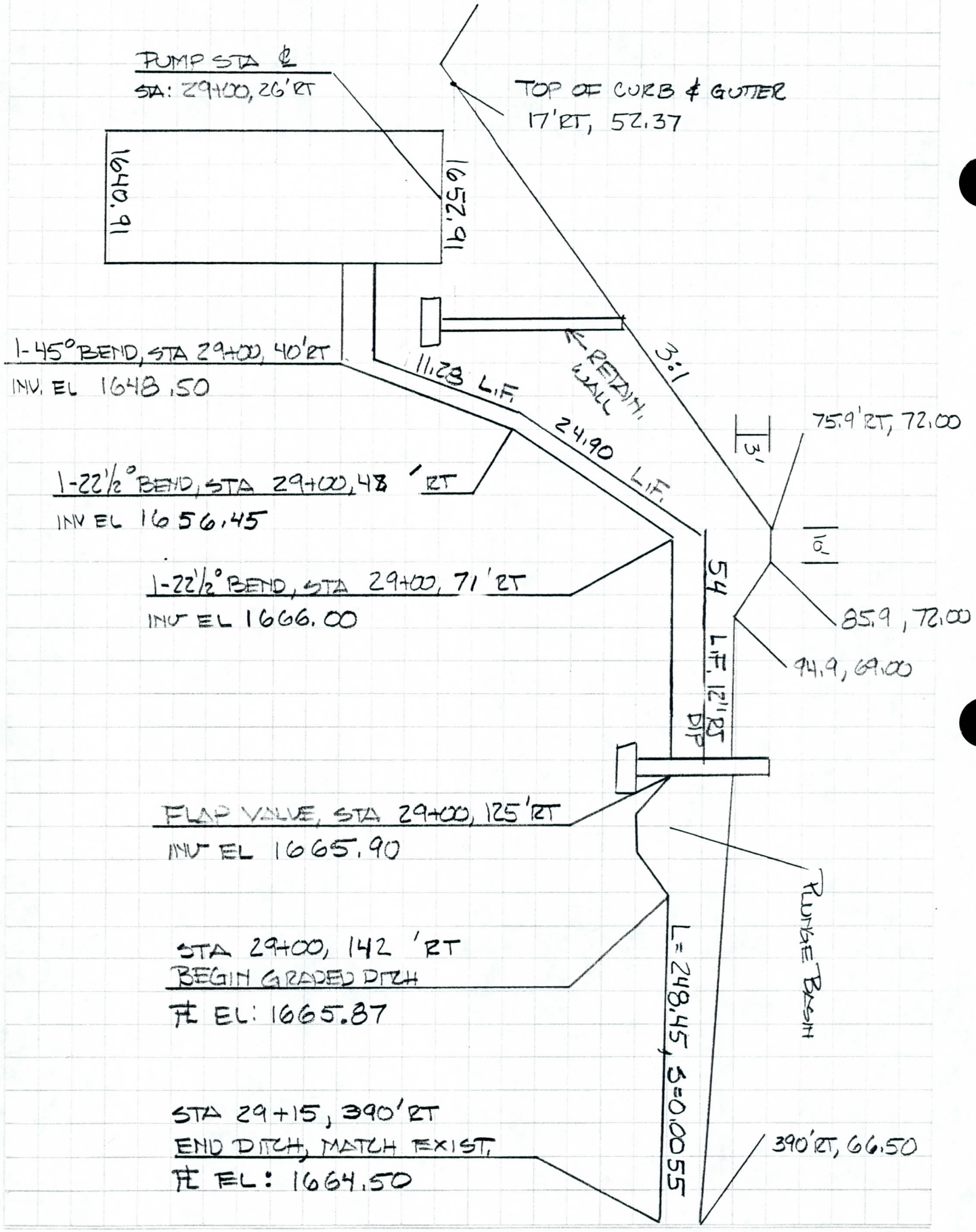
JOB Toyota 40477 SHEET NO. 52 OF 53

COMPUTATIONS FOR Access Road 'A-1' DATE 8/91

BY BGW CHKD



ACCESS ROAD 'A-1' DRAINAGE PROFILE



SVERDRUP

JOB Toledo 4077

COMPUTATIONS FOR Access Road A-1 Detail

DATE 8/91 CHKD BSW

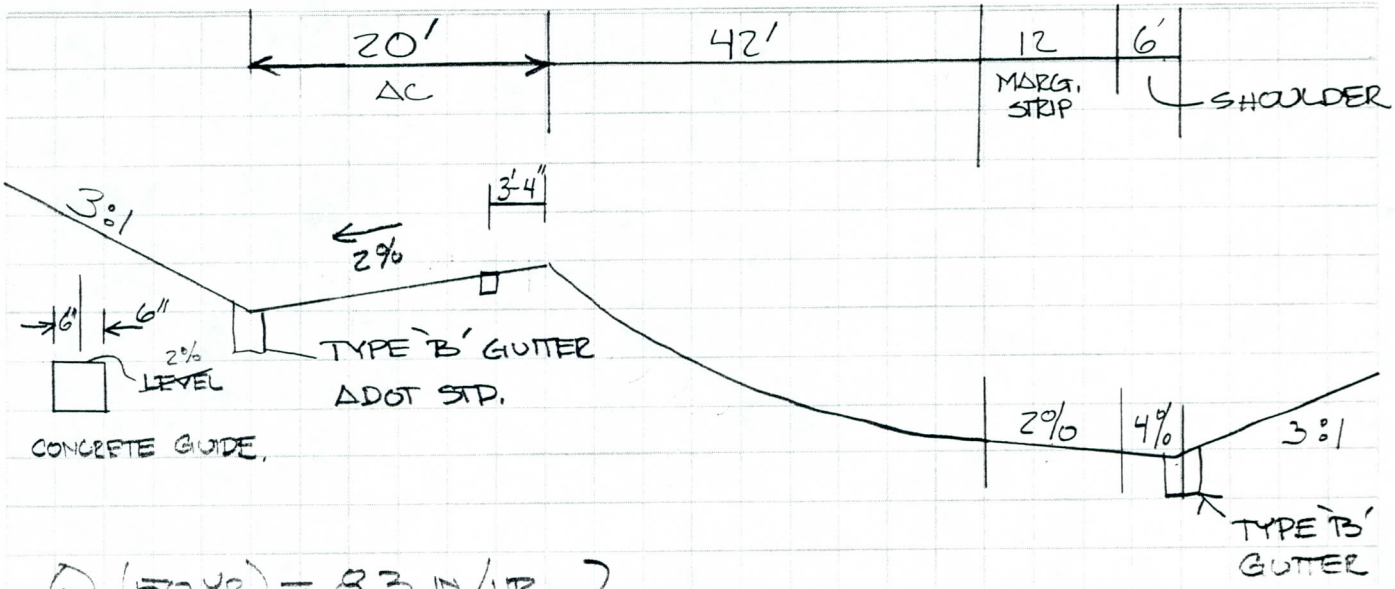
SHEET NO. 53 OF 53

SVERDRUP

JOB TOYOTA 4077 SHEET NO. 1 OF 49

DATE 8/91

COMPUTATIONS FOR TRACK DRAINAGE BY BMW CHKD KJT



Q (50 YR) = 8.3 IN/HR } ADJUSTED AREA INTENSITIES
(10 YR) = 6.1 IN/HR } SEE STEEP GRADES HYDROLOGY.

C (PAVEMENT) = 0.95

(3:1 SLOPE) = 0.40

ASSUMPTIONS:

DESIGN FOR 50 YR STORM WITH A 8 FOOT MINIMUM CLEAR TRAVEL LANE ON BOTH TOP & BOTTOM MAINT. PATHS.

ABOVE & BELOW: CONTINUOUS ADOT TYPE B CURB WITH C-15.91 CATCH BASINS.

SPREAD: FOR ACCESS ROAD, 8' TO REMAIN 'DRY'

SPREAD = 20 - 8' = 12 FT.

FOR MARGINAL STRIP, 0' TO REMAIN 'DRY'

SPREAD = 12 FT + 6' = 18 FT.
(ABOVE GUTTER FLOW LINE)

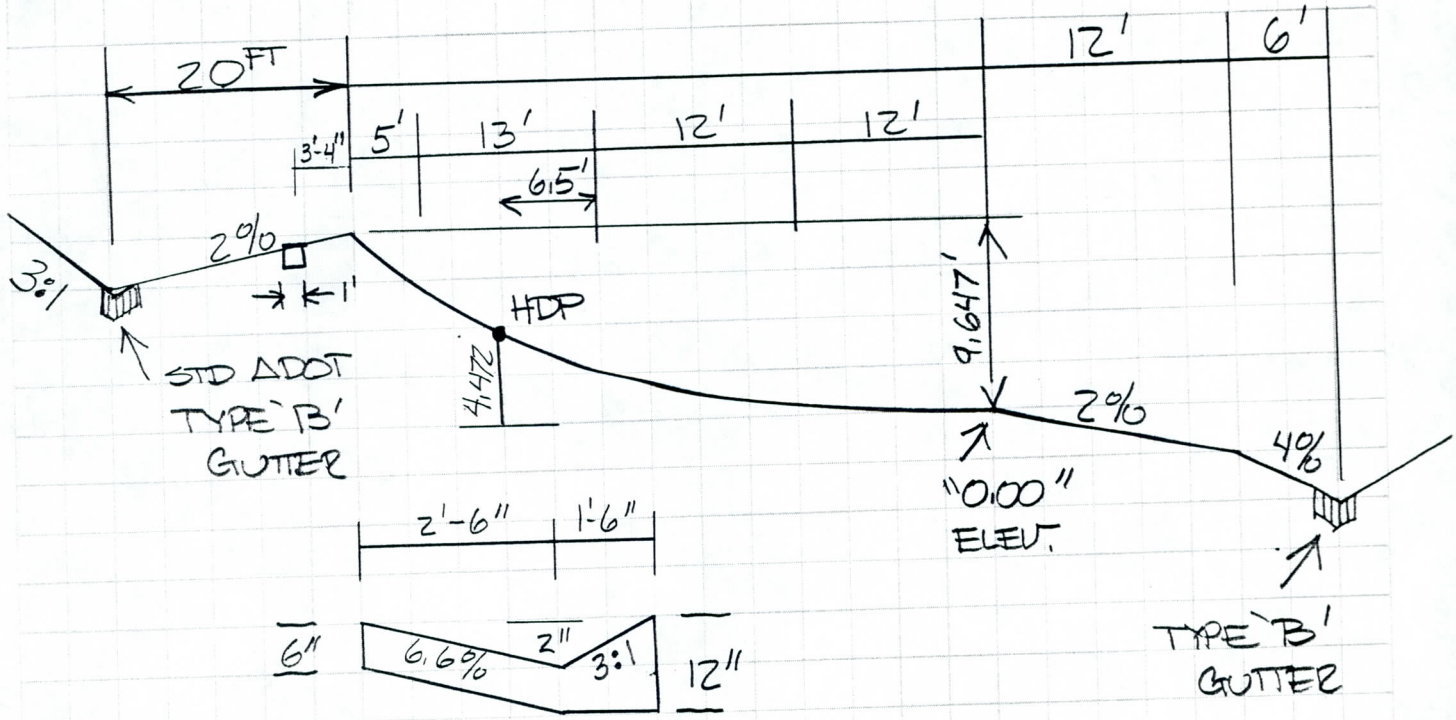
SVERDRUP

JOB TOYOTA 40477 TRACK TYPICAL SECTION

SHEET NO. 2 OF 49

DATE 8/91

COMPUTATIONS FOR IN CURVE (FULL SUPER) BY BSW CHKD RJT



TYPE 'B' GUTTER

HDP = 4.472 FT (IN FULL SUPER ELEVATION)

HI GUTTER = 9.647 - (16.5')(.02) - 2" - 4.472 = 4.678 FT ABOVE HDP.

LO GUTTER = 4.472 + (12)(.02) + (3.5)(.04) + 2" = 5.019 FT BELOW HDP.

★★ NOTE:

THE "HI GUTTER" HAS BEEN DELETED AND REPLACED BY A CHANNEL. THE CALCULATIONS FOR THE "HI GUTTER" ARE LEFT IN THIS REPORT AS THEY WERE USED AS SAMPLE CALCULATIONS FOR THE "LO GUTTER" PORTION.

NOTA TEST TRACK
ECT NO. 40477
DRAINAGE OF NORTHEAST OVAL TRACK SECTION

STATION INCREMENT	ELEVATION HDP	TANGENT GRADE	HI GUTTER EL. DIFF FROM HDP	HI GUTTER ELEVATION HI GUTTER	LO GUTTER EL. DIFF FROM HDP	LO GUTTER ELEVATION LO GUTTER	EXST GRD HI	EXST GRD LO	HI CUT DEPTH	LO CUT DEPTH	HI CUT WIDTH	LO CUT WIDTH	LO GUTTER GRADE
35700	1742.500	-	-	-	1.157	1741.34	-	1738.0	-	0.0	-	0.0	
35800	1742.498	0.001775	-	-	1.160	1741.34	-	1738.2	-	0.0	-	0.0	0.0004
35900	1742.493	0.005429	-	-	1.192	1741.30	-	1738.0	-	0.0	-	0.0	0.0013
36000	1742.481	0.011131	-	-	1.309	1741.17	-	1738.0	-	0.0	-	0.0	0.0027
36100	1742.463	0.018880	-	-	1.562	1740.90	-	1739.8	-	0.0	-	0.0	0.0041
36200	1742.434	0.028677	-	-	1.940	1740.49	-	1739.7	-	0.0	-	0.0	0.0051
36300	1742.393	0.040522	-	-	2.405	1739.99	-	1740.0	-	0.0	-	0.0	0.0057
36400	1742.339	0.054413	-	-	2.920	1739.42	-	1740.5	-	1.1	-	3.2	0.0060
36500	1742.269	0.070353	-	-	3.446	1738.82	-	1740.9	-	2.1	-	6.2	0.0059
36600	1742.180	0.088340	-	-	3.946	1738.23	-	1740.1	-	1.9	-	5.6	0.0054
36700	1742.072	0.108374	-	-	4.380	1737.69	-	1740.5	-	2.8	-	8.4	0.0045
36800	1741.941	0.130456	-	-	4.704	1737.24	-	1742.1	-	4.9	-	14.6	0.0035
36900	1741.787	0.154585	-	-	4.898	1736.89	-	1742.0	-	5.1	-	15.3	0.0027
37000	1741.606	0.180762	-	-	4.990	1736.62	-	1742.2	-	5.6	-	16.8	0.0024
37100	1741.397	0.208987	-	-	5.017	1736.38	-	1741.0	-	4.6	-	13.9	0.0024
37200	1741.158	0.239259	4.678	1745.84	5.019	1736.14	1742.3	1742.0	0.0	5.9	0.0	17.6	0.0027
37300	1740.886	0.271578	4.678	1745.56	5.019	1735.87	1742.1	1742.0	0.0	6.1	0.0	18.4	0.0031
37400	1740.580	0.305945	4.678	1745.26	5.019	1735.56	1742.3	1742.0	0.0	6.4	0.0	19.3	0.0034
37500	1740.239	0.341707	4.678	1744.92	5.019	1735.22	1742.8	1742.1	0.0	6.9	0.0	20.6	0.0038
37600	1739.863	0.376136	4.678	1744.54	5.019	1734.84	1741.8	1741.5	0.0	6.7	0.0	20.0	0.0041
37700	1739.454	0.408518	4.678	1744.13	5.019	1734.43	1740.1	1740.3	0.0	5.9	0.0	17.6	0.0044
37800	1739.015	0.438852	4.678	1743.69	5.019	1734.00	1740.0	1740.0	0.0	6.0	0.0	18.0	0.0047
37900	1738.548	0.467139	4.678	1743.23	5.019	1733.53	1739.8	1739.5	0.0	6.0	0.0	17.9	0.0049
38000	1738.055	0.493378	4.678	1742.73	5.019	1733.04	1738.0	1738.4	0.0	5.4	0.0	16.1	0.0052
38100	1737.537	0.517570	4.678	1742.22	5.019	1732.52	1740.0	1738.0	0.0	5.5	0.0	16.4	0.0054
38200	1736.997	0.539714	4.678	1741.68	5.019	1731.98	1739.0	1738.2	0.0	6.2	0.0	18.7	0.0056
38300	1736.438	0.559810	4.678	1741.12	5.019	1731.42	1737.8	1737.7	0.0	6.3	0.0	18.8	0.0058
38400	1735.860	0.577859	4.678	1740.54	5.019	1730.84	1736.4	1735.8	0.0	5.0	0.0	14.9	0.0059
38500	1735.266	0.593861	4.678	1739.94	5.019	1730.25	1736.0	1735.0	0.0	4.8	0.0	14.3	0.0061
38600	1734.658	0.607815	4.678	1739.34	5.019	1729.64	1735.7	1735.0	0.0	5.4	0.0	16.1	0.0062
38700	1734.038	0.619722	4.678	1738.72	5.019	1729.02	1737.0	1735.8	0.0	6.8	0.0	20.3	0.0063
38800	1733.409	0.629581	4.678	1738.09	5.019	1728.39	1738.5	1738.0	0.4	9.6	1.2	28.8	0.0064
38900	1732.771	0.637393	4.678	1737.45	5.019	1727.75	1735.9	1736.0	0.0	8.2	0.0	24.7	0.0064
39000	1732.128	0.643157	4.678	1736.81	5.019	1727.11	1735.8	1734.8	0.0	7.7	0.0	23.1	0.0065
39100	1731.481	0.646873	4.678	1736.16	5.019	1726.46	1734.0	1730.0	0.0	3.5	0.0	10.6	0.0065
39200	1730.833	0.648545	4.678	1735.51	5.019	1725.81	1734.0	1732.5	0.0	6.7	0.0	20.1	0.0065
39300	1730.184	0.648729	4.678	1734.86	5.019	1725.16	1734.5	1734.0	0.0	8.8	0.0	26.5	0.0065
39400	1729.535	0.648729	4.678	1734.21	5.019	1724.52	1735.0	1734.2	0.8	9.7	2.4	29.1	0.0065
39500	1728.887	0.648729	4.678	1733.56	5.019	1723.87	1734.2	1733.9	0.8	10.0	1.9	30.1	0.0065
39600	1728.238	0.648729	4.678	1732.92	5.019	1723.22	1733.8	1733.0	0.9	9.8	2.7	29.3	0.0065
39700	1727.589	0.648729	4.678	1732.27	5.019	1722.57	1733.8	1733.0	1.5	10.4	4.6	31.3	0.0065
39800	1726.940	0.648729	4.678	1731.62	5.019	1721.92	1733.7	1733.0	2.1	11.1	6.2	33.2	0.0065
39900	1726.292	0.648729	4.678	1730.97	5.019	1721.27	1733.4	1732.8	2.4	11.5	7.3	34.6	0.0065
40000	1725.643	0.648729	4.678	1730.32	5.019	1720.62	1732.5	1732.0	2.2	11.4	6.5	34.1	0.0065
40100	1724.994	0.648729	4.678	1729.67	5.019	1719.98	1733.0	1732.5	3.3	12.5	10.0	37.6	0.0065
40200	1724.345	0.648729	4.678	1729.02	5.019	1719.33	1732.3	1732.5	3.3	13.2	9.8	39.5	0.0065
40300	1723.697	0.648729	4.678	1728.37	5.019	1718.68	1731.8	1731.7	3.4	13.0	10.3	39.1	0.0065
40400	1723.048	0.648729	4.678	1727.73	5.019	1718.03	1730.7	1730.7	3.0	12.7	8.9	38.0	0.0065

OTA TEST TRACK
PROJECT NO. 40477
DRAINAGE OF NORTHEAST OVAL TRACK SECTION

STATION INCREMENT	ELEVATION HDP	TANGENT GRADE	HI GUTTER EL. DIFF FROM HDP	HI GUTTER ELEVATION HI GUTTER	LO GUTTER EL. DIFF FROM HDP	LO GUTTER ELEVATION LO GUTTER	EXST GRD HI	EXST GRD LO	HI CUT DEPTH	LO CUT DEPTH	HI CUT WIDTH	LO CUT WIDTH	LO GUTTER GRADE
40500	1722.399	0.648729	4.678	1727.08	5.019	1717.38	1729.0	1729.0	1.9	11.6	5.8	34.9	0.0065
40600	1721.751	0.648729	4.678	1726.43	5.019	1716.73	1730.0	1728.0	3.6	11.3	10.7	33.8	0.0065
40700	1721.102	0.648729	4.678	1725.78	5.019	1716.08	1729.7	1728.5	3.9	12.4	11.8	37.3	0.0065
40800	1720.453	0.648729	4.678	1725.13	5.019	1715.43	1728.0	1727.0	2.9	11.6	8.6	34.7	0.0065
40900	1719.804	0.648729	4.678	1724.48	5.019	1714.79	1729.0	1728.0	4.5	13.2	13.6	39.6	0.0065
41000	1719.156	0.648729	4.678	1723.83	5.019	1714.14	1729.0	1728.0	5.2	13.9	15.8	41.6	0.0065
41100	1718.507	0.648729	4.678	1723.18	5.019	1713.49	1726.0	1726.0	2.8	12.5	8.4	37.5	0.0065
41200	1717.858	0.648729	4.678	1722.54	5.019	1712.84	1728.0	1727.5	5.5	14.7	16.4	44.0	0.0065
41300	1717.209	0.648729	4.678	1721.89	5.019	1712.19	1726.5	1726.5	4.6	14.3	13.8	42.9	0.0065
41400	1716.561	0.648729	4.678	1721.24	5.019	1711.54	1725.5	1725.5	4.3	14.0	12.8	41.9	0.0065
41500	1715.912	0.648729	4.678	1720.59	5.019	1710.89	1724.0	1724.0	3.4	13.1	10.2	39.3	0.0065
41600	1715.263	0.648729	4.678	1719.94	5.019	1710.24	1723.5	1722.5	3.6	12.3	10.7	36.8	0.0065
41700	1714.614	0.648729	4.678	1719.29	5.019	1709.60	1723.5	1722.9	4.2	13.3	12.6	39.9	0.0065
41800	1713.966	0.648729	4.678	1718.64	5.019	1708.95	1723.0	1722.4	4.4	13.5	13.1	40.4	0.0065
41900	1713.317	0.648729	4.678	1718.00	5.019	1708.30	1722.0	1722.0	4.0	13.7	12.0	41.1	0.0065
42000	1712.668	0.648729	4.678	1717.35	5.019	1707.65	1720.0	1720.3	2.7	12.7	8.0	38.0	0.0065
42100	1712.020	0.648729	4.678	1716.70	5.019	1707.00	1718.3	1719.0	1.6	12.0	4.8	36.0	0.0065
42200	1711.371	0.648729	4.678	1716.05	5.019	1706.35	1718.2	1717.0	2.2	10.6	6.5	31.9	0.0065
42300	1710.722	0.648729	4.678	1715.40	5.019	1705.70	1717.7	1717.0	2.3	11.3	6.9	33.9	0.0065
42400	1710.073	0.648729	4.678	1714.75	5.019	1705.05	1716.0	1716.3	1.2	11.2	3.7	33.7	0.0065
42500	1709.425	0.648729	4.678	1714.10	5.019	1704.41	1714.5	1714.5	0.4	10.1	1.2	30.3	0.0065
42600	1708.776	0.648729	4.678	1713.45	5.019	1703.76	1714.0	1714.0	0.5	10.2	1.6	30.7	0.0065
42700	1708.127	0.648729	4.678	1712.81	5.019	1703.11	1713.8	1712.5	1.0	9.4	3.0	28.2	0.0065
42800	1707.478	0.648729	4.678	1712.16	5.019	1702.46	1713.0	1712.5	0.8	10.0	2.5	30.1	0.0065
42900	1706.830	0.648729	4.678	1711.51	5.019	1701.81	1712.7	1712.0	1.2	10.2	3.6	30.6	0.0065
43000	1706.181	0.648729	4.678	1710.86	5.019	1701.16	1712.0	1711.5	1.1	10.3	3.4	31.0	0.0065
43100	1705.532	0.648729	4.678	1710.21	5.019	1700.51	1710.5	1710.0	0.3	9.5	0.9	28.5	0.0065
43200	1704.884	0.648729	4.678	1709.56	5.019	1699.86	1709.0	1708.5	0.0	8.6	0.0	25.9	0.0065
43300	1704.235	0.648729	4.678	1708.91	5.019	1699.22	1708.2	1707.8	0.0	8.6	0.0	25.8	0.0065
43400	1703.586	0.648729	4.678	1708.26	5.019	1698.57	1707.0	1707.0	0.0	8.4	0.0	25.3	0.0065
43500	1702.937	0.648729	4.678	1707.62	5.019	1697.92	1706.3	1706.0	0.0	8.1	0.0	24.2	0.0065
43600	1702.289	0.648729	4.678	1706.97	5.019	1697.27	1705.0	1704.2	0.0	6.9	0.0	20.8	0.0065
43700	1701.640	0.648729	4.678	1706.32	5.019	1696.62	1704.0	1703.3	0.0	6.7	0.0	20.0	0.0065
43800	1700.991	0.648729	4.678	1705.67	5.019	1695.97	1702.8	1702.5	0.0	6.5	0.0	19.6	0.0065
43900	1700.342	0.648729	4.678	1705.02	5.019	1695.32	1702.0	1701.5	0.0	6.2	0.0	18.5	0.0065
44000	1699.694	0.648729	4.678	1704.37	5.019	1694.67	1700.0	1700.0	0.0	5.3	0.0	16.0	0.0065
44100	1699.045	0.648729	4.678	1703.72	5.019	1694.03	1699.0	1699.0	0.0	5.0	0.0	14.9	0.0065
44200	1698.396	0.648729	4.678	1703.07	5.019	1693.38	1698.5	1698.0	0.0	4.6	0.0	13.9	0.0065
44300	1697.747	0.648729	4.678	1702.43	5.019	1692.73	1697.5	1696.0	0.0	3.3	0.0	9.8	0.0065
44400	1697.099	0.648729	4.678	1701.78	5.019	1692.08	1696.2	1696.0	0.0	3.9	0.0	11.8	0.0065
44500	1696.450	0.648729	4.678	1701.13	5.019	1691.43	1695.5	1695.5	0.0	4.1	0.0	12.2	0.0065
44600	1695.801	0.648729	4.678	1700.48	5.019	1690.78	1693.5	1694.0	0.0	3.2	0.0	9.7	0.0065
44700	1695.153	0.648729	4.678	1699.83	5.019	1690.13	1692.5	1693.0	0.0	2.9	0.0	8.6	0.0065
44800	1694.504	0.648729	4.678	1699.18	5.019	1689.48	1692.2	1692.2	0.0	2.7	0.0	8.1	0.0065
44900	1693.855	0.648729	4.678	1698.53	5.019	1688.84	1691.0	1691.0	0.0	2.2	0.0	6.5	0.0065
45000	1693.206	0.648729	4.678	1697.88	5.019	1688.19	1689.0	1691.0	0.0	2.8	0.0	8.4	0.0065
45100	1692.558	0.648729	4.678	1697.24	5.019	1687.54	1690.0	1690.5	0.0	3.0	0.0	8.9	0.0065
45200	1691.909	0.648729	4.678	1696.59	5.019	1686.89	1688.5	1688.5	0.0	1.6	0.0	4.8	0.0065

KOTA TEST TRACK
JECT NO. 40477
DRAINAGE OF NORTHEAST OVAL TRACK SECTION

STATION INCREMENT	ELEVATION HDP	TANGENT GRADE	HI GUTTER EL. DIFF FROM HDP	HI GUTTER ELEVATION HI GUTTER	LO GUTTER EL. DIFF FROM HDP	LO GUTTER ELEVATION LO GUTTER	EXST GRD HI	EXST GRD LO	HI CUT DEPTH	LO CUT DEPTH	HI CUT WIDTH	LO CUT WIDTH	LO GUTTER GRADE
45300	1691.260	0.648729	4.678	1695.94	5.019	1686.24	1688.0	1688.5	0.0	2.3	0.0	6.8	0.0065
45400	1690.611	0.648729	4.678	1695.29	5.019	1685.59	1687.5	1688.0	0.0	2.4	0.0	7.2	0.0065
45500	1689.963	0.648729	4.678	1694.64	5.019	1684.94	1687.0	1687.5	0.0	2.6	0.0	7.7	0.0065
45600	1689.314	0.648729	4.678	1693.99	5.019	1684.30	1686.5	1687.0	0.0	2.7	0.0	8.1	0.0065
45700	1688.665	0.648729	4.678	1693.34	5.019	1683.65	1686.1	1686.2	0.0	2.6	0.0	7.7	0.0065
45800	1688.017	0.648729	4.678	1692.69	5.019	1683.00	1685.0	1685.0	0.0	2.0	0.0	6.0	0.0065
45900	1687.368	0.648729	4.678	1692.05	5.019	1682.35	1684.0	1684.0	0.0	1.7	0.0	5.0	0.0065
46000	1686.719	0.648729	4.678	1691.40	5.019	1681.70	1682.3	1683.5	0.0	1.8	0.0	5.4	0.0065
46100	1686.070	0.648729	4.678	1690.75	5.019	1681.05	-	1682.5	-	1.4	-	4.3	0.0065
46200	1685.422	0.648729	4.678	1690.10	5.019	1680.40	-	1682.0	-	1.6	-	4.8	0.0065
46300	1684.773	0.648729	4.678	1689.45	5.019	1679.75	-	1680.5	-	0.7	-	2.2	0.0065
46400	1684.124	0.648729	4.678	1688.80	5.019	1679.11	-	1679.8	-	0.7	-	2.1	0.0065
46500	1683.475	0.648729	4.678	1688.15	5.019	1678.46	-	1679.0	-	0.5	-	1.6	0.0065
46600	1682.827	0.648729	4.678	1687.50	5.019	1677.81	-	1678.1	-	0.3	-	0.9	0.0065
46700	1682.178	0.648729	4.678	1686.86	5.019	1677.16	-	1677.5	-	0.3	-	1.0	0.0065
46800	1681.529	0.648729	4.678	1686.21	5.019	1676.51	-	1676.3	-	0.0	-	0.0	0.0065
46900	1680.881	0.648729	4.678	1685.56	5.019	1675.86	-	1675.0	-	0.0	-	0.0	0.0065
47000	1680.232	0.648729	4.678	1684.91	5.019	1675.21	-	1674.0	-	0.0	-	0.0	0.0065
47100	1679.583	0.648729	4.678	1684.26	5.019	1674.56	-	1672.5	-	0.0	-	0.0	0.0065
47200	1678.934	0.648729	4.678	1683.61	5.019	1673.92	-	1671.3	-	0.0	-	0.0	0.0065
47300	1678.285	0.648729	4.678	1682.96	5.019	1673.27	-	1670.2	-	0.0	-	0.0	0.0065
47400	1677.637	0.648729	4.678	1682.31	5.019	1672.62		1668.0	-	0.0	-	0.0	0.0065

* SEE PAGE 3

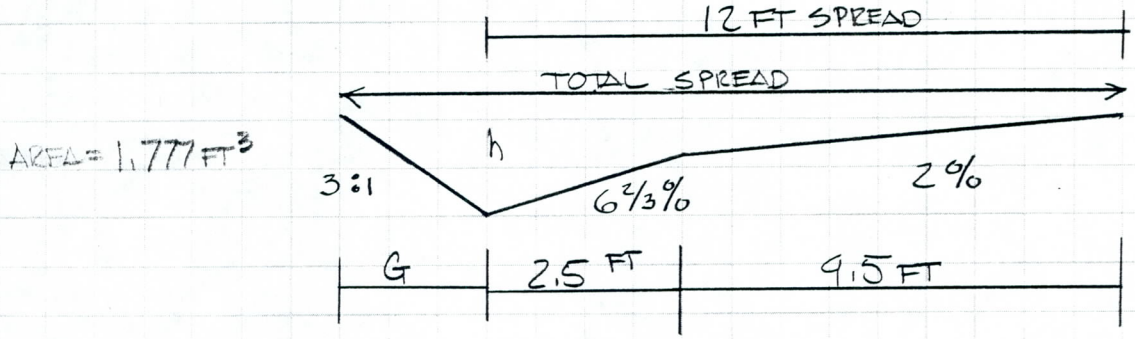
SVERDRUP

JOB TOYOTA 40477 SHEET NO. 6 OF 49

DATE 8/91

COMPUTATIONS FOR TRACK DRAIN (NE) BY BSW CHKD RJT

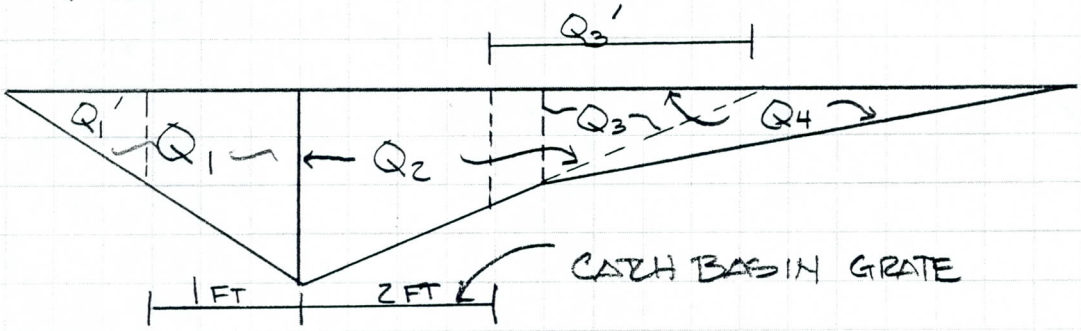
MAINT. ROAD ABOVE TRACK : HIGH GUTTER



AREA = 1.777 FT²

"h" = (2.5)(.06̄6) + (9.5)(.02) = .357 FT

G = (3)(h) = 3(.357) = 1.07 FT



FOR TRIANGULAR SECTION

$$Q = \frac{0.56}{n} S_x^{5/3} S^{1/2} T^{8/3} \qquad \text{(EQ. \#4, HEC 12)}$$

$n = 0.016$ $S = 0.0065$ 1/FT

$$Q_1 = \frac{0.56}{0.016} (.33\bar{3})^{5/3} (.0065)^{1/2} (1.07)^{8/3} = 0.542 \text{ cfs}$$

$$Q_2 = \frac{0.56}{0.016} (.06\bar{6})^{5/3} (.0065)^{1/2} (.357/.06\bar{6})^{8/3} = 2.715 \text{ cfs}$$

$$Q_3 = \frac{0.56}{0.016} (.06\bar{6})^{5/3} (.0065)^{1/2} ((.357/.06\bar{6}) - 2.5)^{8/3} = 0.507 \text{ cfs}$$

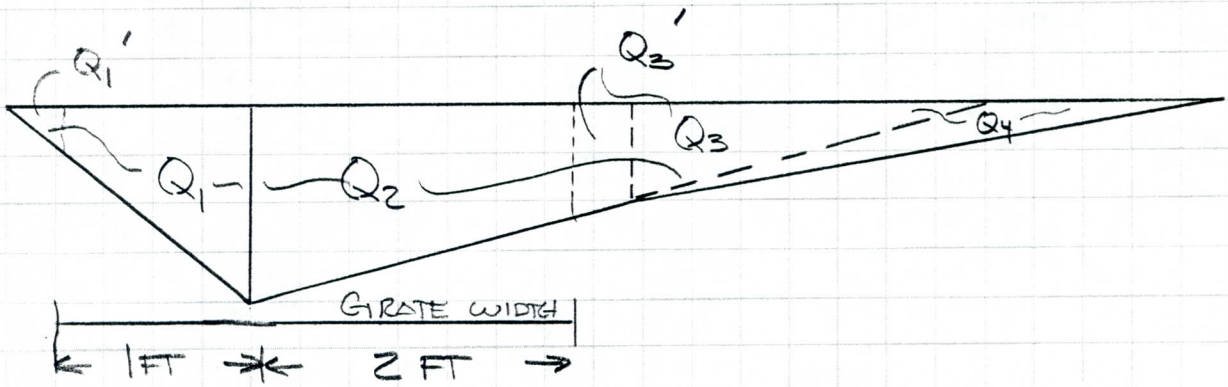
$$Q_4 = \frac{0.56}{0.016} (.02)^{5/3} (.0065)^{1/2} (9.5)^{8/3} = 1.683 \text{ cfs}$$

SVERDRUP

JOB TOYOTA 40477 SHEET NO. 7 OF 49

COMPUTATIONS FOR N.E. TRACK DRAIN DATE 8/91

BY BSW CHKD RJT



E_o = FRONTAL FLOW EFFICIENCY

$$= Q_W / Q$$

Q_W = WATER OVER GRATE = $Q_1 + Q_2 - Q_1' - Q_3'$

Q = TOTAL Q

$$= \frac{Q_1 + Q_2 - Q_3' - Q_1'}{Q_1 + Q_2 - Q_3 + Q_4}$$

FOR MAX SPREAD: (DEPTH = .357)

$Q_1' = 0$

$$Q_3' = \frac{0.56}{.016}(.0\bar{6})^{5/8}(.0065)^{1/2}((.357/.0\bar{6}) - 2)^{8/3}$$

$$= .780 \text{ cfs}$$

SVERDRUP

JOB TOYOTA 40477 SHEET NO. 8 OF 49

COMPUTATIONS FOR N.E. TRACK DRAIN DATE 8/91 BY BSW CHKD RJT

Q (GUTTER) @ MAX SPREAD

$= Q_1 + Q_2 - Q_3 + Q_4$

$= 0.542 + 2.715 - 0.507 + 1.683 = 4.433$ cfs

$V_{ELOCITY\ AUG} = \frac{Q}{A} = \frac{4.433 \text{ cfs}}{1.777 \text{ FT}^2} = 2.495$ FT/SEC.

$V_{ELOCITY\ (OVER\ GRATE)} \cong \frac{(Q_2 - Q_3)}{(A_2 - Q_3)} = (2.715 - .507)/(.956 - .217) = 3.23 \frac{FT}{S}$

E_o = FRONTAL FLOW EFFICIENCY. (HEC 12, CHART 4) $= "Q_W"/"Q"$

Q_W = Q OF WATER DIRECTLY OVER GRATE

$= Q_1 + Q_2 - Q_1' - Q_3'$ $\quad (Q_1' = 0,\ Q_3' = .780$ ↑ FROM COMPUTER 2 SPREAD SHEET)

$Q = Q_{TOTAL} = Q_1 + Q_2 + Q_3 - Q_4.$

$E_o = (0.542 + 2.715 - 0 - .780)/(.542 + 2.715 - 0.507 + 1.683) = .559$

R_F (CHART 7, HEC 12) = 1.0 (SEE NEXT PAGE)

R_S (CHART 8, HEC 12) "S_X" = 0.02, R_S = 0.06

L = 1.5 FT ⇒ (3 FT GRATE w/ 50% CLOG.)

$E = R_F E_o + R_s (1 - E_o)$ (EQ 11, HEC 12)

$= (.559) + .06 (1 - .559) = .586$

$Q_i = E\ Q = .586\ (4.433 \text{ cfs}) = 2.598$ cfs (EQ 12, HEC 12)

$Q_b = Q - Q_b = 4.433 - 2.598 = 1.835$ cfs

SVERDRUP

JOB TOYOTA 40477 SHEET NO. 9 OF 49

DATE 8/91

COMPUTATIONS FOR TRACK DRAIN. (N.E.) BY BJW CHKD RJT

CAPACITY OF GRATED INLETS ON CONTINUOUS GRADE

FOR CLOGGING FACTORS, USE 50% (ADOT DESIGN PROCED. MANUAL)

GRATES: TYPE: PER STD DETAIL C-15.91

LENGTH OF GRATE = 3 FT
WIDTH OF GRATE = 3 FT

DEPTH OF GRATE BARS = $3\frac{1}{2}$"

$$L_b = \frac{V}{2}(d + d_b)^{1/2}$$ (ADOT HYDRAULIC TRAIN. MAN. PG F-11)

L_b = LENGTH OF GRATE REQ. TO INTERCEPT ALL FLOW OVER GRATE (FT)
V = VELOCITY OVER GRATE OPENING, fps

d = DEPTH OF FLOW (FT)

d_b = DEPTH OF BAR (= 3.5 INCH) = .292 FT

FOR CLOGGING OF 50%, $L_b \leq 3(.50) = 1.5$ FT

IF $L_b \leq 1.5$ FT, $R_F = 1.0$

IF $L_b > 1.5$ FT, $R_F = 1.5/L_b$

FOR SIDE FLOW CLOGGING, USE Δ GRATE LENGTH OF 1.5 FT IN CHART 8, HEC 12.

CATCH BASIN DESIGN: CATCH BASIN CALCULATION SHEET

LOCATION DATA

HIGHWAY: TOYOTA, USA TEST TRACK

LOCATION: N/E TRACK SECTION, HIGH GUTTER

PROJECT NO.: 40477

LOCATION			DRAINAGE AREA			I	Q	Q c	Qt	So	SLOTTED DRAIN			GRATED INLET		
CB NO.	FROM	TO	Length ft.	W ft.	CA Acres	IN/HR	CFS	CFS	CFS	ft/ft	T ft	L ft.	Qb CFS	T ft.	V FPS	Qb CFS
	393+00	403+00	1000	7	0.529	8.3	4.39	0.00	4.39	0.0065	12.9	10	1.94	8.8	2.60	0.48
L1	403+00	406+25	325	9	0.179	8.3	1.49	0.48	1.96	0.0065	8.8	10	0.45	3.1	1.73	0.01
L2	406+25	409+50	325	12	0.188	8.3	1.56	0.01	1.57	0.0065	7.8	10	0.26	2.5	1.50	0.00
L3	409+50	412+75	325	14	0.193	8.3	1.60	0.00	1.60	0.0065	7.9	10	0.28	2.5	1.52	0.00
L4	412+75	416+00	325	13	0.191	8.3	1.59	0.00	1.59	0.0065	7.9	10	0.27	2.5	1.51	0.00
L5	416+00	419+25	325	12	0.187	8.3	1.55	0.00	1.55	0.0065	7.8	10	0.26	2.5	1.50	0.00
L6	419+25	422+50	325	8	0.176	8.3	1.46	0.00	1.46	0.0065	7.6	10	0.22	2.3	1.44	0.00
L7	422+50	425+75	325	4	0.164	8.3	1.36	0.00	1.36	0.0065	7.3	10	0.18	2.2	1.37	0.00
L8	425+75	429+00	325	3	0.160	8.3	1.33	0.00	1.33	0.0065	7.2	10	0.17	2.1	1.35	0.00
L9	429+00	432+00	300	2	0.146	8.3	1.21	0.00	1.21	0.0065	6.8	10	0.13	1.9	1.26	0.00
L10	432+00	OUTFALL		0												

VOID
SEE PAGE 3

CATCH BASIN DESIGN: CATCH BASIN CALCULATION SHEET

LOCATION DATA

HIGHWAY: TOYOTA, USA TEST TRACK

LOCATION: N/E TRACK SECTION, HIGH GUTTER

PROJECT NO.: 40477

LOCATION			DRAINAGE AREA			I	Q	Q c	Qt	So	SLOTTED DRAIN			GRATED INLET		
CB NO.	FROM	TO	Length ft.	W ft.	CA Acres	IN/HR	CFS	CFS	CFS	ft/ft	T ft	L ft.	Qb CFS	T ft.	V FPS	Qb CFS
	393+00	403+00	1000	7	0.529	8.3	4.39	0.00	4.39	0.0065	12.9	10	1.94	8.8	2.60	0.48
L1	403+00	406+25	325	9	0.179	8.3	1.49	0.48	1.96	0.0065		0	1.96	8.8	2.61	0.49
L2	406+25	409+50	325	12	0.188	8.3	1.56	0.49	2.05	0.0065		0	2.05	9.1	2.65	0.54
L3	409+50	412+75	325	14	0.193	8.3	1.60	0.54	2.14	0.0065		0	2.14	9.2	2.66	0.57
L4	412+75	416+00	325	13	0.191	8.3	1.59	0.57	2.15	0.0065		0	2.15	9.3	2.67	0.58
L5	416+00	419+25	325	12	0.187	8.3	1.55	0.58	2.13	0.0065		0	2.13	9.3	2.67	0.58
L6	419+25	422+50	325	8	0.176	8.3	1.46	0.58	2.04	0.0065		0	2.04	9.0	2.63	0.52
L7	422+50	425+75	325	4	0.164	8.3	1.36	0.52	1.88	0.0065		0	1.88	8.6	2.57	0.45
L8	425+75	429+00	325	3	0.160	8.3	1.33	0.45	1.77	0.0065		0	1.77	8.4	2.53	0.40
L9	429+00	432+00	300	2	0.146	8.3	1.21	0.40	1.61	0.0065	7.9	10	0.28	2.5	1.52	0.00
L10	432+00	OUTFALL		0												

VOID
SEE R-3

☆ SEE PAGE 3

SVERDRUP

JOB TOYOTA 40477

COMPUTATIONS FOR N.E. TRACK DRAIN.

SHEET NO. 10 OF 49

DATE 8/91

BY BSW CHKD RJT

DRAINAGE SYSTEM DESIGN FOR HIGH GUTTER

CATCH BASIN SPACING:

$Q = CiA$ $i(50YR) = 8.3$ IN/HR (SEE STEEP GRADES HYDROLOGY.)

$C = 0.95$ FOR PAVEMENT
0.40 FOR EARTH SLOPES

WIDTH OF PAVEMENT + GUTTER = 21.5 FT

WIDTH OF EARTH CUT SLOPES = 14 FT
(HIGH AUG FOR 300 FT LENGTH)

$$Q = 2.598 \text{ cfs} = (8.3 \text{ IN/HR}) \left(\frac{(.95)(21.5) + (14)(.40)}{43,560} \right) L$$

$L = 523.91$ FT

FOR 24 INCH PIPE, MAX CATCH BASIN / MANHOLE SPACING

= 330 FT (ADOT)

FOR 30 INCH, = 330 FT

FOR 36 INCH, = 440 FT.

USE ADOT MAX SPACING.

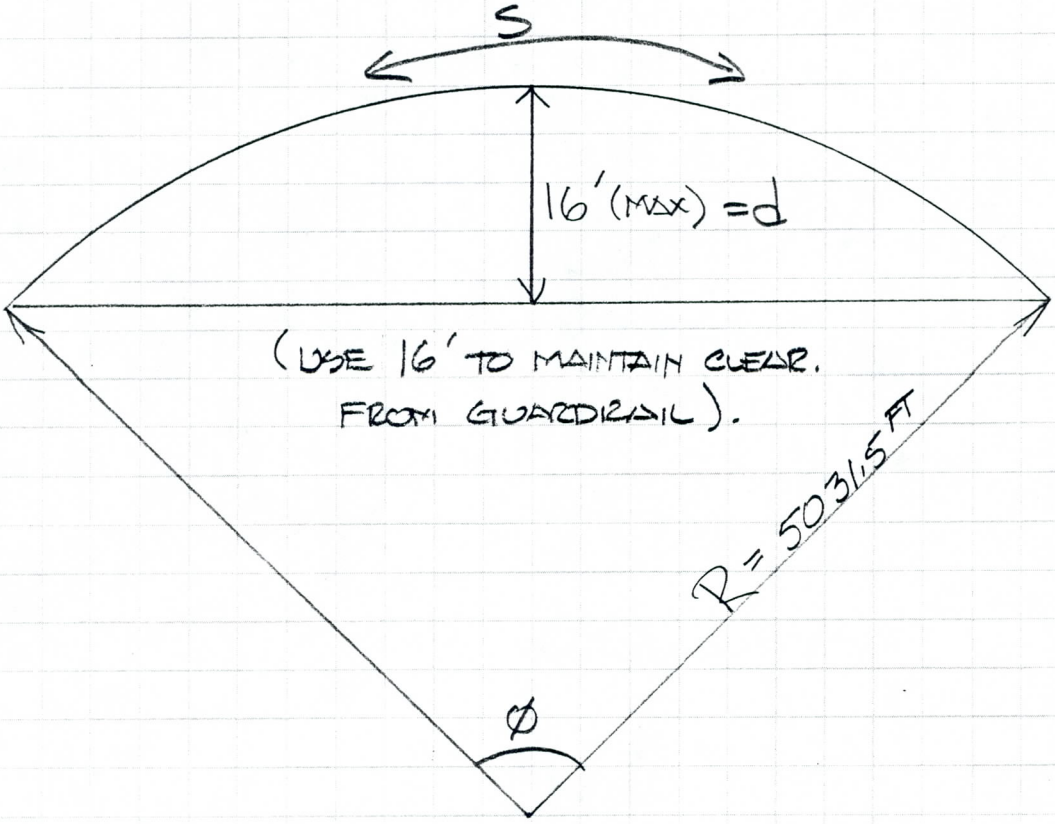
SVERDRUP

JOB TOYOTA 40477 SHEET NO. 13 OF 49

DATE 8/91

COMPUTATIONS FOR TRACK DRAIN, OUTSIDE GUTTER BY BSW CHKD RJT

CHECK MAXIMUM SPACING OF CATCH BASINS:



FOR THE TOP STORM DRAIN ABOVE THE TEST TRACK, CHECK FOR THE MIDDLE ORDINATE TO STAY WITHIN THE MAINT. ROAD.

$R = 5031.5$ FT

$$\emptyset = 2\left(\text{ARCOS}.\frac{r-d}{r}\right) = 2\left(\text{ARCOS}\ \frac{(5031.5-16)}{5031.5}\right)$$

$$= 9.141^{\circ} = 9.141 \times \frac{2\pi}{360} = .159$$

$$\emptyset = \frac{S}{r} \qquad S = r\emptyset = .159(5031.5)$$

$$= 802.72 \text{ FT.}$$

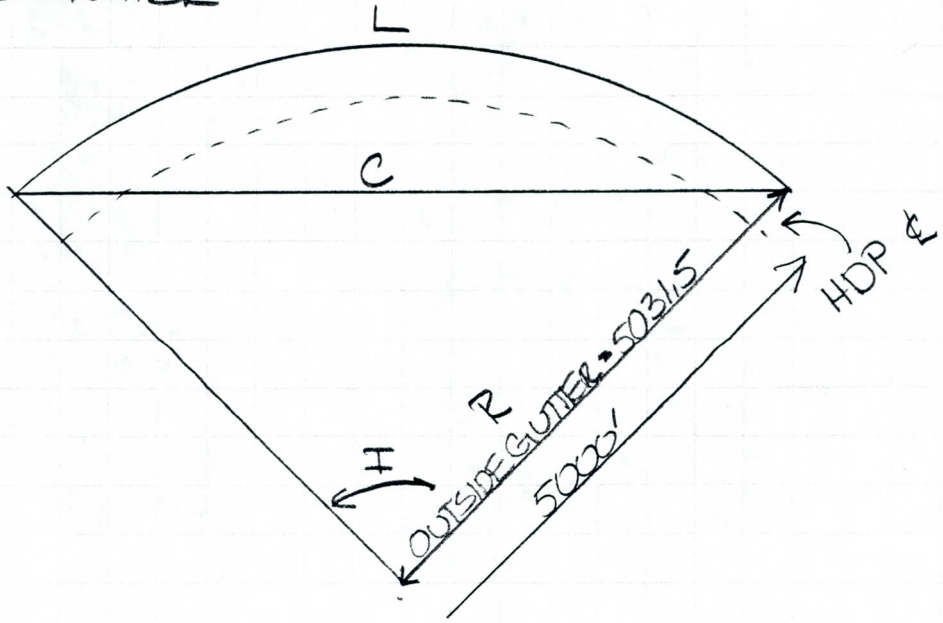
SVERDRUP

JOB TOYOTA 40477 SHEET NO. 14 OF 49

COMPUTATIONS FOR N.E. TRACK DRAIN DATE 8/91

BY BSW CHKD RJT

OUTSIDE GUTTER



FOR 325' STATIONING

$$L = R\,I \Rightarrow 325 \Rightarrow (5000)\,I\left(\frac{2\pi}{360}\right)$$

$$I = 3.724^\circ$$

$$C = 2R\,\sin(I/2) = 2(5031.5)\sin\left(\frac{3.724}{2}\right)$$

$$C = 326.99$$

(ADOT CRITERIA RESTRICTS 24" PIPE TO HAVE MANHOLES OR CATCH BASINS EVERY 330 FEET. EVEN STATIONING IS DESIRED SO 325 FT IS USED.)

SVERDRUP

JOB Toyota 40477 SHEET NO. 15 OF 49

DATE 8/91

COMPUTATIONS FOR NE. TRACK DRAIN BY BGW CHKD RJT

DISTANCE (MAX.) FROM BEGINNING OF CUT TO 1ST CATCH BASIN (HIGH GUTTER ABOVE TRACK.)

$$Q = CiA$$

$$4.433^{cfs} = 8.3(IN/HR)\left[\frac{(L \times 215 \times .95) + (L \times 7 \times .40)}{43560}\right]$$

$$4.433 = \frac{8.3\ L(20.425 + 2.8)}{43,560}$$

(AUG BASIN WIDTH FOR SLOPED EARTH FOR 1ST 1500 FT = 7FT)

$$L = 1001.73\ FT$$

LOCATE 1ST CATCH BASIN @ 1000 FT AFTER START OF CUT.

SPACE REMAINING CATCH BASINS AT MAXIMUM SPACING PER ADOT SPECIFICATIONS (< 523 FT.) ← CALCS.

ADOT MAX: 24 IN. PIPE = 330 FT
30 IN. PIPE = 330 FT
36 IN. PIPE = 440 FT

★ SEE PAGE 3

SVERDRUP

JOB TOYOTA 40477 SHEET NO. 16 OF 49

COMPUTATIONS FOR NE. TRACK DRAIN DATE 8/91

BY BSW CHKD RJT

★ SAMPLE STORM SEWER CALCULATION (HIGH GUTTER)

PIPE RUN "L5" (SEE FOLLOWING CALC SHEET FOR SEWER DESIGN) STA 416+00 TO 419+25

STATION DISTANCE = 325 FT

THE STORM WATER ENTERING THE PIPE @ STA 416+00 IS FROM THE BASIN WITH STATION LIMITS 412+75 TO 416+00

BASIN LENGTH ≈ 325 FT

BASIN WIDTH

STATION	WIDTH
412+00	16.4
413+00	13.8
414+00	12.8
415+00	10.2
416+00	10.7

AVG WIDTH ≅ 12.8 FT

$$CA = L \times \left[\frac{(.95)(\text{PAVED AREA}) + (.40)(\text{BASIN WIDTH})}{43,560} \right]$$

("C", PAVED; "C", UNPAVED)

AVG PAVED AREA = 20 FT + 1.5 FT GUTTER = 21.5 FT

$$= 325 \left[\frac{(.95)(21.5) + (.40)(12.8)}{43,560} \right] = 0.191 \text{ ACRES}$$

CA FOR THIS REACH IS 0.191 ACRES, THIS IS ADDED TO THE PREVIOUS Σ CA FOR THE TOTAL DRAINAGE AREA.

SVERDRUP

JOB TOYOTA 40477 SHEET NO. 17 OF 49

COMPUTATIONS FOR N.E. TRACK DRAIN DATE 8/91

BY BSW CHKD RJT

ΣCA = CA (STA 393+00 to STA 412+75) +

CA (STA 412+75 TO STA 416+00)

= 1.095 + .191 = 1.286 ACRES

↑ Σ STA 393+00 TO 412+75, SEE FOLLOWING SPREAD SHEET

TIME OF FLOW IS BASED ON THE GREATER OF THE FOLLOWING:

1) INDIVIDUAL CONCENTRATION TIME OF A REACH

T_c = 4.9 MIN = AUG (SEE NEXT PAGE)

2) T_c (MINIMUM) = 5.0 MIN BY COUNTY REQ.

3) INLET TIME + TIME FOR WATER TO FLOW THROUGH THE PIPE TO THE REACH

= T_{c_1} + Σ SEWER FLOW TIMES.

(3 IS MOST COMMONLY THE LARGEST).

FOR THIS REACH T_{c_1} = 4.9 MIN + 2.94 MIN (PREV SEWER)

+ .86 MIN (TIME FOR FLOW TO TRAVEL FROM STA 412+75 TO 416+00, SEE CALCS, LATER IN THIS SAMPLE)

T_c = 8.70 MIN

FROM HDMMC FIG 3.3, @ T_c = 8.7 MIN, $i_{50_{PHX}}$ = 6.5 IN/HR

$$i_{TOYOTA} = i_{PHX}\left[\frac{P_{10}^6}{2.07}\right] = 6.5\left[\frac{2.15}{2.07}\right] = 6.8 \text{ IN/HR}$$

SVERDRUP

JOB TOYOTA 40477 SHEET NO. 18 OF 49

COMPUTATIONS FOR N.E. TRACK DRAIN DATE 3/91

BY BMW CHKD RTT

CONCENTRATION TIME

$$T_c = 11.4\ L^{0.5}\ K_b^{0.52}\ S^{-0.31}\ i^{-0.38} \quad \text{(EQ. 3.2, HDM/MC)}$$

$L = 330.3' = .0626$ MILE

$K_b = m \log A + b$

$m = -.01375$

$b = 0.08$

HIGH CUT WIDTH / PAVE. AREA

$A = 330 \times (14 + 22) / 43560 = .273$ ACRES

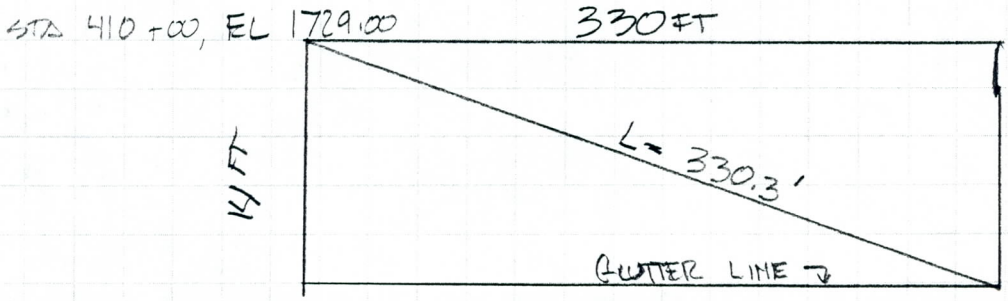
$= .0878$

$S = (1729.00 - 1721.69) / .0626 = 116.85$ FT/MILE

$i = 8.3$ IN/HR (5 MIN DURATION, 50 YR STORM)

$T_c = 0.0823$ HR $= 4.94$ MIN.

USE $T_c = 4.9$ MIN FOR INDIVIDUAL FLOW TIMES TO EACH BASIN.



SVERDRUP

JOB TOYOTA 40477 SHEET NO. 19 OF 49

COMPUTATIONS FOR N.E. TRACK DRAIN DATE 8/91

BY BSW CHKD RTT

FROM MARICOPA COUNTY HYDROLOGIC DESIGN MANUAL

(FIG. 3.2)

T_c (MIN)	i_{PHX} (50 YR)	i_{PHX} (2 YR)
5	8.05	3.8
5.5	7.75	3.7
6	7.5	3.6
6.5	7.3	3.5
7	7.1	3.4
7.5	6.9	3.3
8	6.7	3.2
8.5	6.55	3.1
9	6.4	3.05
9.5	6.3	3.0
10	6.2	2.9
11	6.0	2.8
12	5.75	2.7
13	5.55	2.6
14	5.4	2.5
15	5.3	2.4
16	5.2	2.3
17	5.0	2.25
18	4.8	2.2
19	4.6	2.15
20	4.5	2.1

FOR PHX METRO AREA

FOR THE TOYOTA FACILITY,

$$i_{TOYOTA} = i_{PHX}\left[\frac{P_{10}^{6}}{2.07}\right] = i_{PHX}\left[\frac{2.15}{2.07}\right]$$

(SEE CALC. SHEET)

SVERDRUP

JOB TOYOTA 40477 SHEET NO. 20 OF 49

COMPUTATIONS FOR H.E. TRACK DRAIN DATE 8/91

BY BSW CHKD RJT

$Q = CiA$ RATIONAL EQUATION

$\Rightarrow \Sigma CA = 1.286$ ACRES (SEE SPREAD SHEET)
= Σ CA STA 393+00 TO 419+25

$i = 6.8$ IN/HR (PREV. CALC.)

$Q = (1.286)(6.8) = 8.745$ cfs.

Q (PIPE FLOWING FULL)

$= \frac{1.486}{n} A (r_h)^{2/3} S^{1/2}$

$n \Rightarrow$ (HDPEP) $= 0.010$

$A \Rightarrow$ (24" PIPE) $= \frac{1}{4}\pi (2)^2 = 3.14$ FT^2

$r_h = \frac{D}{4} = .5$ FT

$S = .0062$ FT/FT

$Q = \frac{1.486}{.010} (3.14)(.5)^{2/3} (.0062)^{1/2}$

$= 23.16$ cfs

$V_{FULL} = Q/A = 23.16 \text{ cfs} / 3.14 = 7.37$ FT/SEC

V (ACTUAL VELOCITY @ Q = 8.745cfs) $\Rightarrow$

$Q_{PIPE}/Q_{FULL} = 8.745/23.16 = .38$

SVERDRUP

JOB Toyota 40477 SHEET NO. 21 OF 49

DATE 8/91

COMPUTATIONS FOR N.E. TRACK DRAIN BY BSW CHKD RJT

(SEE "APPEN C", ENG. REF. MANUAL, ATTACHED.)

WHEN $Q_{PIPE}/Q_{FULL} = .38$, $V_{PIPE}/V_{FULL} = .91$

$V_{PIPE} = V\ (ACTUAL) = .91\ (7.37\ FT/SEC)$

$= 6.7\ FT/SEC$

FOR WATER TO FLOW FROM STA 420+00 TO 423+25

$L = 326.99\ FT$ (CHORD LENGTH)

$$T = \frac{L}{V} = \frac{326.99\ FT}{6.7\ F/SEC} = \frac{48.76\ SEC}{60\ SEC/MIN}$$

$= .81$ MIN.

SEWER LAYOUT

MINIMUM COVER = 2 FT

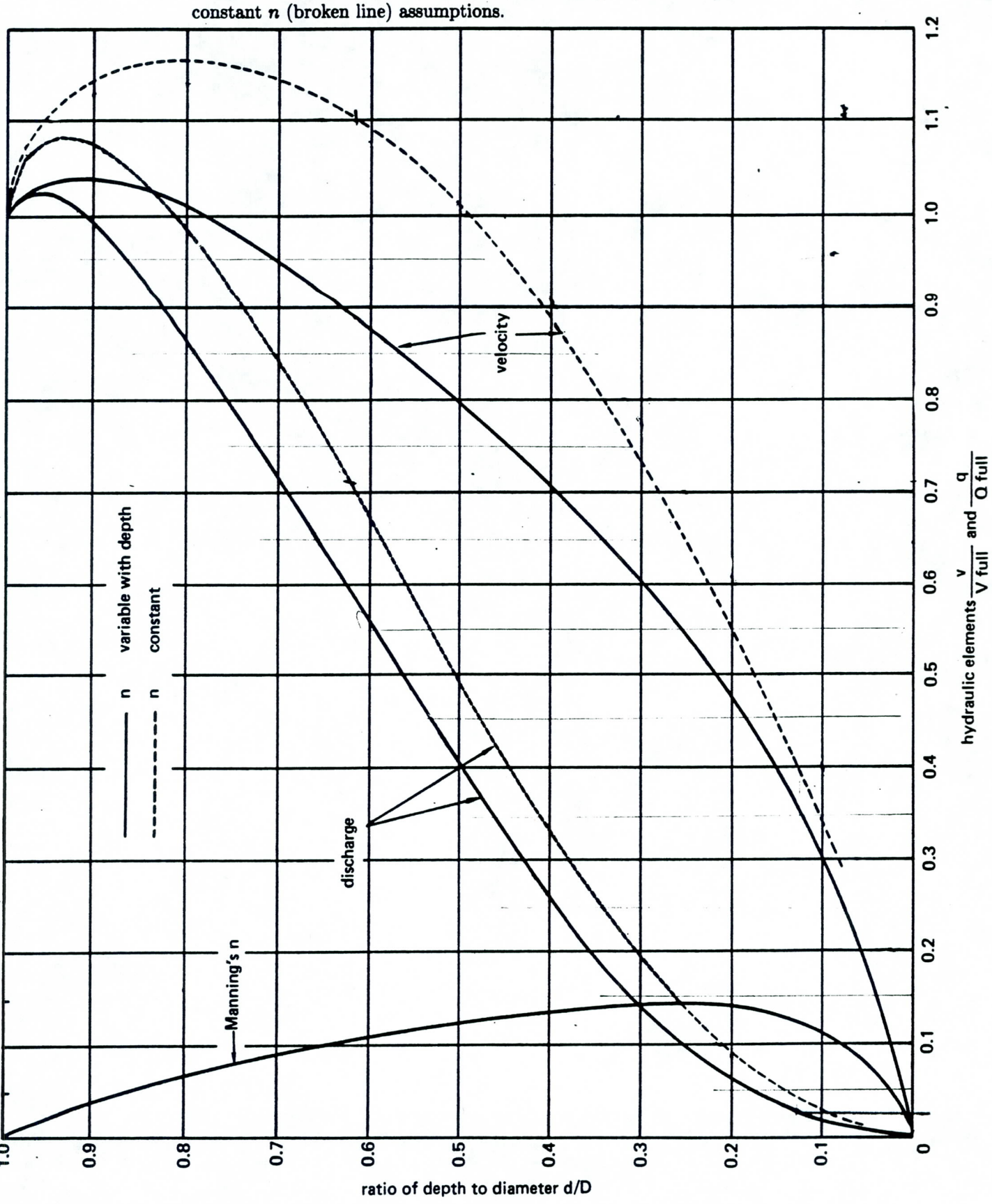
MINIMUM VELOCITY = 2 FT/SEC

MINIMUM COVER IF SLOTTED DRAIN IS USED = 3 FT

DROP IN CATCH BASIN = 0.1 FT EACH.

Appendix C: Circular Channel Ratios

Experiments have shown that n varies slightly with depth. This figure gives velocity and flow rate ratios for varying n (solid line) and constant n (broken line) assumptions.



STORM SEWER DESIGN: SEWER CALCULATION SHEET

LOCATION DATA

HIGHWAY: TOYOTA, USA TEST TRACK
LOCATION: N/E TRACK SECTION, HIGH GUTTER
PROJECT NO.: 40477

DESIGN DATA

FREQUENCY: 50.00 (YEAR)

SEWER CALCULATIONS

LOCATION			DRAINAGE AREA			TIME OF FLOW (MIN.)			I	Q	SEWER PROFILE				SEWER DESIGN					
											INV. ELEVATION		LENGTH	SLOPE	DIAM.	n	Q FULL	V FULL	V ACT.	FLOW
LINE NO.	FROM	TO	NO.	INCREM. CA	Σ CA	INLET	SEWER	DESIGN	(in/hr)	(CFS)	INLET	OUTLET	(ft)	(ft/ft)	(in)		(CFS)	(FPS)	(FPS)	(MIN.)
	393+00	403+00	: LIMITS OF INITIAL DRAINAGE INTO SYSTEM																	
L1	403+00	406+25		0.533	0.533	4.9		5.00	8.36	4.46	1723.26	1721.25	326.99	0.0062	24	0.010	23	7.4	5.0	1.1
L2	406+25	409+50		0.179	0.712	4.9	1.09	5.00	8.36	5.96	1721.13	1719.12	326.99	0.0062	24	0.010	23	7.4	5.9	.9
L3	409+50	412+75		0.188	0.901	4.9	0.92	6.91	7.48	6.74	1719.01	1717.00	326.99	0.0062	24	0.010	23	7.4	5.9	.9
L4	412+75	416+00		0.194	1.095	4.9	0.92	7.84	7.06	7.73	1716.88	1714.87	326.99	0.0062	24	0.010	23	7.4	6.3	.9
L5	416+00	419+25		0.191	1.286	4.9	0.86	8.70	6.80	8.75	1714.75	1712.74	326.99	0.0062	24	0.010	23	7.4	6.6	.8
L6	419+25	422+50		0.188	1.474	4.9	0.82	9.52	6.54	9.65	1712.62	1710.65	326.99	0.0061	24	0.010	23	7.3	6.9	.8
L7	422+50	425+75		0.176	1.650	4.9	0.78	10.30	6.39	10.54	1710.53	1708.55	326.99	0.0061	24	0.010	23	7.3	7.2	.8
L8	425+75	429+00		0.164	1.815	4.9	0.76	11.06	6.23	11.31	1708.43	1706.46	326.99	0.0061	24	0.010	23	7.3	7.2	.8
L9	429+00	432+00		0.161	1.976	4.9	0.76	11.82	6.04	11.93	1706.34	1704.52	301.85	0.0061	24	0.010	23	7.3	7.5	.7
L10	432+00	OUTFALL		0.146	2.122	4.9	0.67	12.50	5.92	12.56	1704.41				24					

VOID - SEE PG 3

STORM SEWER DESIGN: PIPE ELEVATION SUMMARY

LOCATION DATA

HIGHWAY: TOYOTA, USA TEST TRACK

LOCATION: N/E TRACK SECTION, HIGH GUTTER

PROJECT NO.: 40477

LOCATION			SEWER PROFILE						
LINE NO.	FROM	TO	INV. ELEVATION		GUTTER ELEVATION		LENGTH (FT.)	SLOPE (FT/FT)	DIAM. (IN.)
			INLET	OUTLET	INLET	OUTLET			
L1	403+00	406+25	1723.16	1721.15	1728.27	1726.16	326.99	0.0062	24
L2	406+25	409+50	1721.03	1719.02	1726.16	1724.06	326.99	0.0062	24
L3	409+50	412+75	1718.91	1716.90	1724.06	1721.95	326.99	0.0062	24
L4	412+75	416+00	1716.78	1714.77	1721.95	1719.84	326.99	0.0062	24
L5	416+00	419+25	1714.65	1712.64	1719.84	1717.74	326.99	0.0062	24
L6	419+25	422+50	1712.52	1710.55	1717.74	1715.62	326.99	0.0061	24
L7	422+50	425+75	1710.43	1708.45	1715.62	1713.51	326.99	0.0061	24
L8	425+75	429+00	1708.33	1706.36	1713.51	1711.41	326.99	0.0061	24
L9	429+00	432+00	1706.24	1704.42	1711.41	1710.21	301.85	0.0061	24
L10	432+00	OUTFALL	1704.31		1709.46				24

VOID

SEE PAGE 3

$TW/Y_o = 3.2'/1.49' = 2.15 > 0.75$ ∴ Check downstream riprap lining for channel.

Utilize figure XI-3 for estimating average velocity along channel. Compute equivalent circular diameter D_e for brink area from:

$A = \pi D_e^2/4 = Y_o W_o = 1.49(10) = 14.9\ ft^2$

$D_e = (14.9(4)/\pi)^{1/2} = 4.36'$

From downstream cross section Q10 Velocity is 3.4 fps. Culvert outlet velocity is 9.6 fps.

L/D_e	L	V_L/V_o	V_L	
10	43.6	.59	5.66	
15	65.4	.36	3.46	~ 3.4 fps (OK)

∴ Need riprap lining for approximately 65' from end of culvert outlet apron.

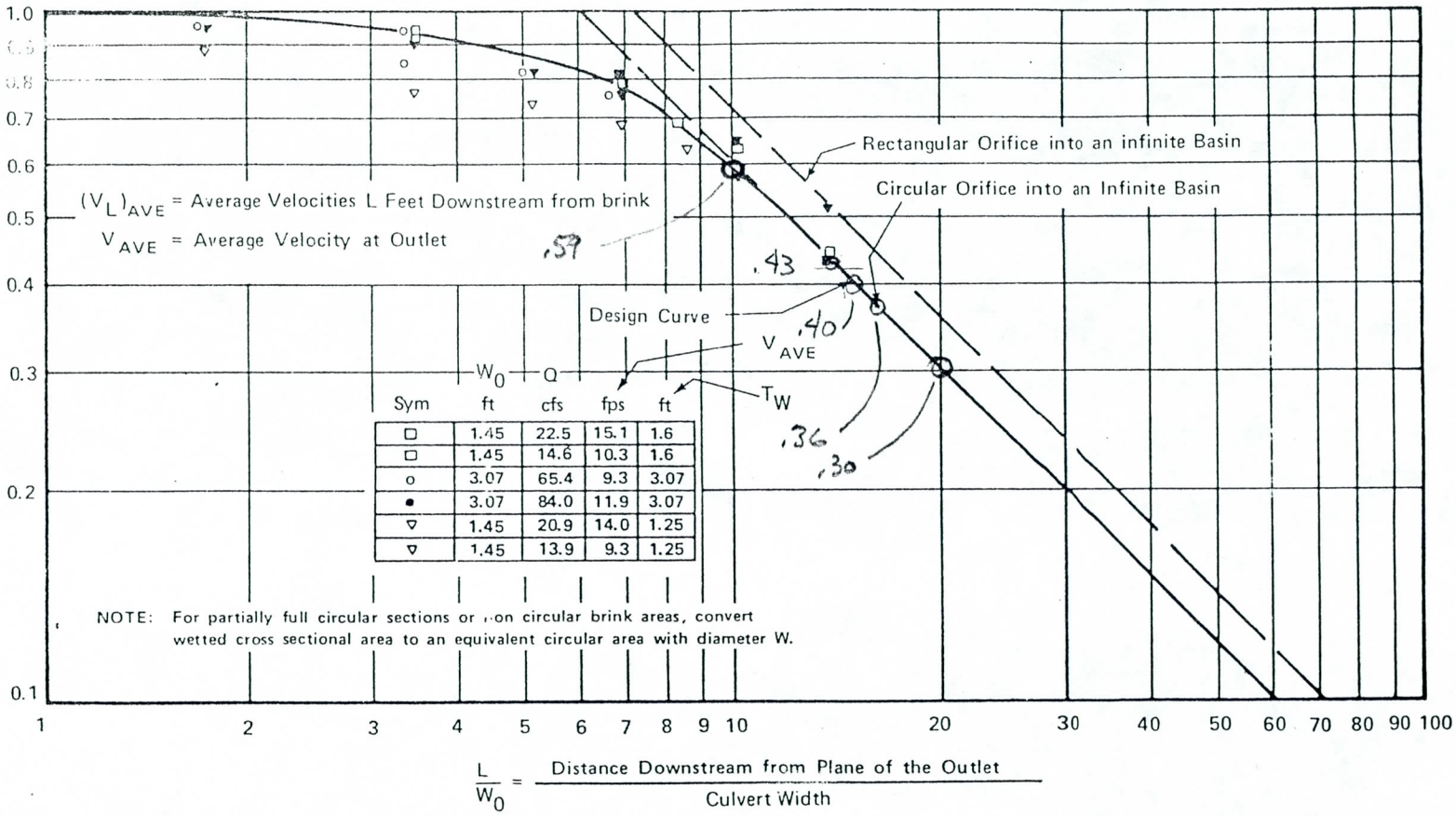


Figure XI - 3 Distribution of Centerline Velocity for Flow from Submerged Outlets from Reference XI - 2. to be used for Predicting Channel Velocities Downstream from Culvert Outlet where High Tailwater prevails. Velocities obtained from the use of this Chart can be used with Figure 2 of HEC No. 11 for sizing riprap (DO not use Figure 1 HEC No. 11, use Mean Velocity Values)

SVERDRUP

JOB 40477 Toyota

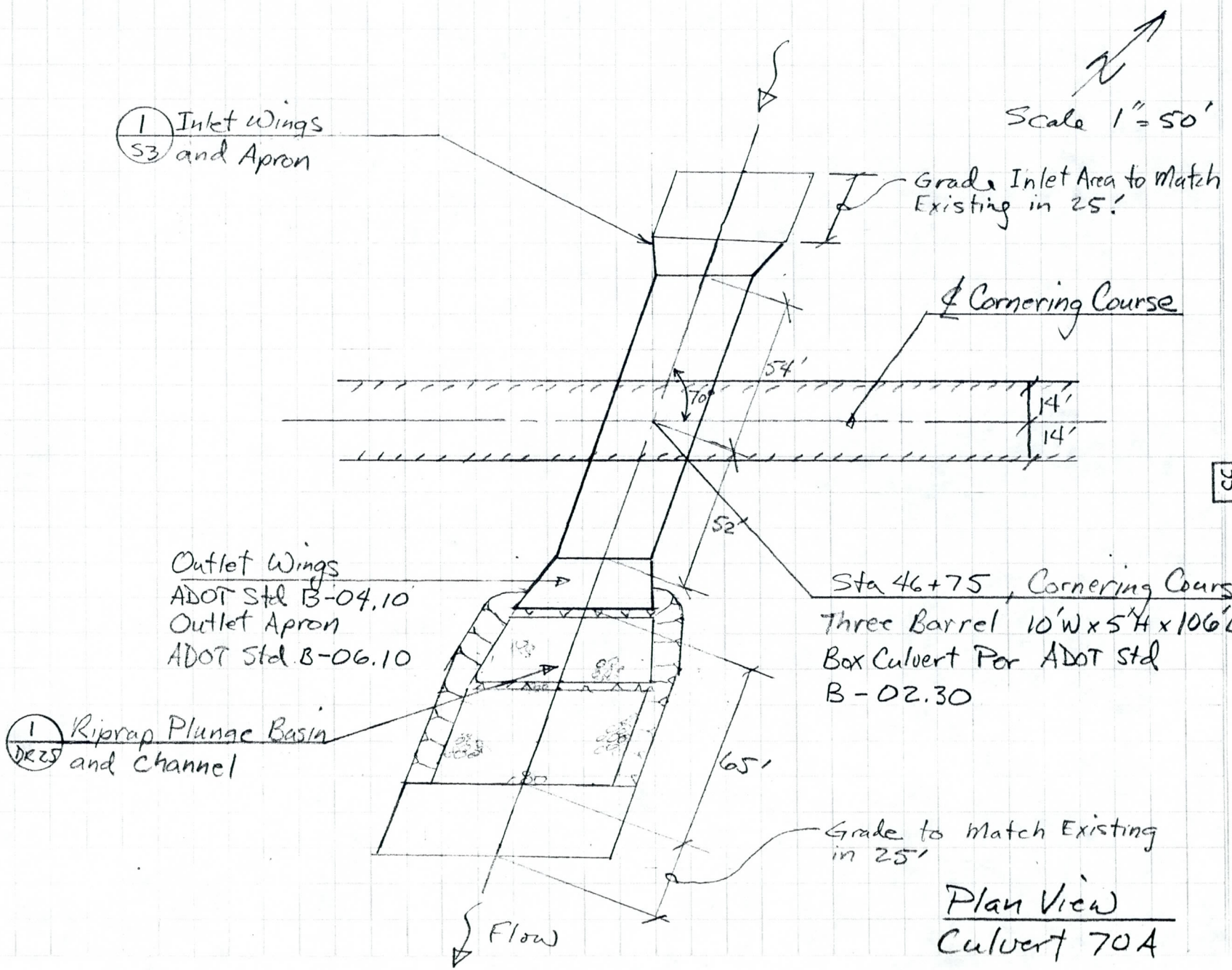
COMPUTATIONS FOR Plan View Culvert 70A

35

SHEET NO. 10 OF

DATE 6/7/91

BY BDO CHKD RJT



Plan View
Culvert 70A

SVERDRUP

JOB TOYOTA 40477 SHEET NO. 25 OF 49

COMPUTATIONS FOR N.E. TRACK DRAIN DATE 8/91

BY BSW CHKD RJT

FOR THE "LOW GUTTER" DESIGN, THE FOLLOWING EQUATIONS HAVE BEE INCORPORATED INTO A SPREAD SHEET.

$$V = Q/A$$

$$Q = \frac{0.56}{n} S_x^{5/3} S^{1/2} T^{8/3} \quad (EQ\ \#4,\ HEC\ 12)$$

n = GUTTER MANNING COEF. = 0.016

S_x = CROSS SLOPE T = SPREAD

S = LONG. SLOPE

$E_o = Q_w/Q$ ⇒ Q_w = FLOW DIRECTLY OVER GRATE, Q = TOTAL FLOW

R_F = FRONTAL FLOW INTERCEPTION EFFICIENCY
(SEE SHEET 09 FOR DETAILED EXPLANATION)

R_S = GRATE INLET SIDE FLOW INTERCEPTION EFFICIENCY
(EQ 10, HEC 12) (CHART 8, HEC 12) $R_s = 1 \Big/ \left(1 + \frac{.15\, V^{1.8}}{S_x\, L^{2.3}}\right)$

E = GRATE EFFICIENCY = $R_F E_o + R_S (1 - E_o)$
(EQ. 11, HEC 12)

Q_i = INTERCEPTION CAPACITY (EQ 12, HEC 12)

Q_b = BY-PASS FLOW = $Q - Q_i$

SVERDRUP

JOB TOYOTA 40477 SHEET NO. 26 OF 49

COMPUTATIONS FOR N.E. TRACK DRAIN DATE 8/91 BY BSW CHKD RVT

$Q = CiA$ RATIONAL EQUATION

L_T = LENGTH OF SLOTTED DRAIN REQUIRED TO INTERCEPT ALL FLOW

$$= 0.6\, Q^{0.42} S^{0.3} \left(\frac{1}{n\, S_e}\right)^{0.6} \quad \text{(HEC 12, EQ 16)}$$

$n = 0.016$

$S_e = S_x + S_w' E_o$ (EQ 15, HEC 12)

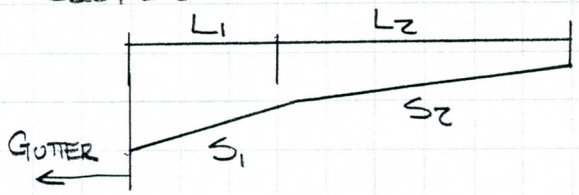
S_W = DIFF BETWEEN GUTTER & PAVE. SLOPE

$S_W' = a/W$ = GUTTER $S - S_x$

$= 0.066 - S_x$

S_x = PAVEMENT CROSS SLOPE, ADJACENT TO GUTTER

USE WEIGHTED AVG FOR PAVEMENT SLOPES



$$S_x = \frac{L_1 S_1 + L_2 S_2}{L_1 + L_2}$$

E (SLOTTED DRAIN)

$$= 1 - (1 - L/L_T)^{1.8} \quad \text{(EQ 14, HEC 12).}$$

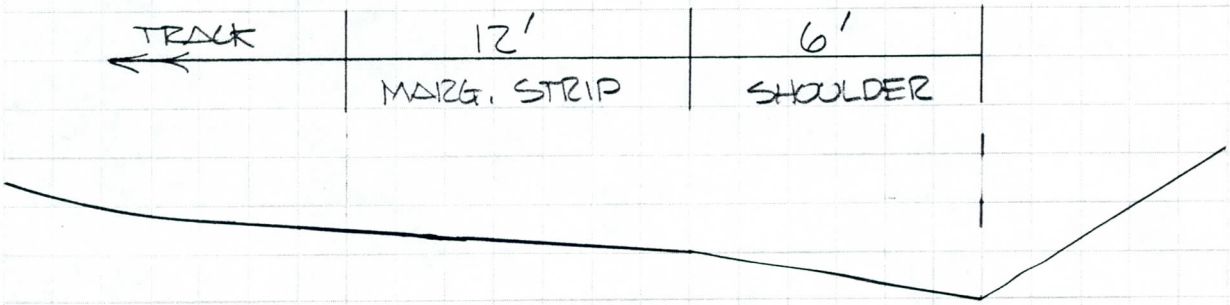
SVERDRUP

JOB TOYOTA 40477 SHEET NO. 27 OF 49

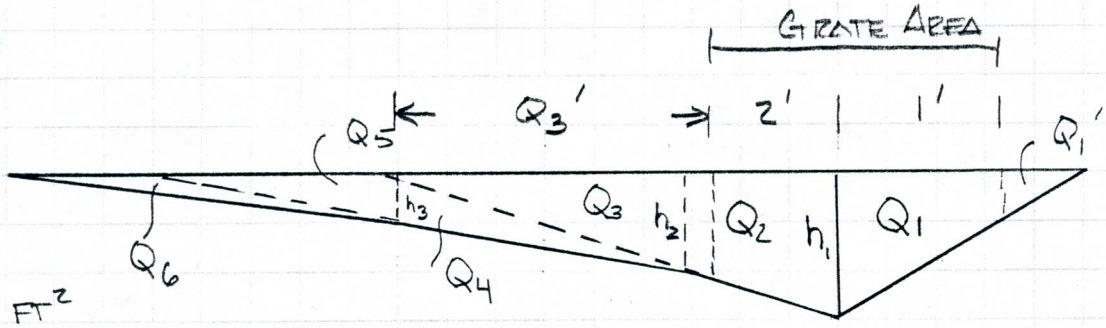
DATE 8/91

COMPUTATIONS FOR N.E. TRACK DRAIN BY BMW CHKD RJT

"LOW GUTTER" DESIGN



NO REMAINING TRAVEL LANE ON MARGINAL STRIP, DURING 50 YR STORM EVENT.



AREA = 4.33 FT²

12'	3.5'	2.5'	G
2%	4%	6.6%	3:1

FOR MAX. SPREAD:

$h_1 = 2.5(.06\overline{6}) + 3.5(.04) + 12(.02) = .547$ FT

$G = 3(h_1) = 3(.547) = 1.64$ FT

$h_2 = 12(.02) + 3.5(.04) = 0.38$ FT

$h_3 = 12(.02) = 0.24$ FT

$S = 0.0065$ 1/FT

$n = 0.016$

$T = 19.64$ FT = MAXIMUM SPREAD ALLOWED

SVERDRUP

JOB TOYOTA 40477 SHEET NO. 28 OF 49

COMPUTATIONS FOR N.E TRACK DRAIN DATE 8/91

BY BWS CHKD RTT

FOR TRIANGULAR SECTION:

$$Q = \frac{0.56}{n} S_x^{5/3} S^{1/2} + 8/3 \qquad (EQ\#4, HEC\ 12)$$

$$Q_1 = \frac{0.56}{0.016} (.3\bar{3})^{5/3} (.0065)^{1/2} (1.64)^{8/3} = 1.694 \text{ cfs}$$

$$Q_2 = \frac{0.56}{0.016} (.0\bar{6})^{5/3} (.0065)^{1/2} (.547/.0\bar{6})^{8/3} = 8.469 \text{ cfs}$$

$$Q_3 = \frac{0.56}{0.016} (.0\bar{6})^{5/3} (.0065)^{1/2} (.547/.0\bar{6} - 2.5)^{8/3} = 3.215 \text{ cfs}$$

$$Q_4 = \frac{0.56}{0.016} (.04)^{5/3} (.0065)^{1/2} (.38/.04)^{8/3} = 5.358 \text{ cfs}$$

$$Q_5 = \frac{0.56}{.016} (.04)^{5/3} (.0065)^{1/2} (.38/.04 - 3.5)^{8/3} = 1.575 \text{ cfs}$$

$$Q_6 = \frac{0.56}{.016} (.02)^{5/3} (.0065)^{1/2} (12)^{8/3} = 3.150 \text{ cfs}$$

$$Q_G (\text{GUTTER TOTAL}) = Q_1 + Q_2 - Q_3 + Q_4 - Q_5 + Q_6$$

$$= 13.881 \text{ cfs}$$

$$\text{VELOCITY} = Q/A = 13.881 / 4.138 \text{ FT}^2 = 3.35 \text{ FT/SEC.}$$

= AVG FOR SECTION

$$V_{GRATE} \cong \frac{(Q_2 - Q_3)}{(2.244 - 1.093)} = \frac{(8.469 - 3.215)}{(2.244 - 1.093)} = 4.53 \text{ FT/SEC}$$

$E_o = Q_w / Q$ (HEC 12, CHART 4)

$Q_w = Q_1 + Q_2 - Q_1' - Q_3'$

$Q_1' = .138$ cfs

$Q_3' = 4.02$ cfs (COMP. SPREAD SHEET)

$Q = Q_1 + Q_2 - Q_3 + Q_4 - Q_5 + Q_6$

$E_o = (1.694 + 8.469 - .138 - 4.02) / (1.694 + 8.469 - 3.215 + 5.358 - 1.575 + 3.150)$

$= 0.433$

$R_F \Rightarrow$ (CHART 7, HEC 12) $= 1.0$ (SEE PAGE 9)

$R_S \Rightarrow$ (CHART 8, HEC 12) $\Rightarrow R_S = 0.028$

$L = 1.5$ FT (3.0 FT GRATE w/ 50% CLOG)

$V = 4.53$ FT/SEC

$S_x = \frac{(3.5)(.04) + (12)(.02)}{3.5 + 12} = 0.025$

$E = R_F E_o + R_S (1 - E_o)$ (EQ 11, HEC 12)

$= 1.0(.433) + .028(1 - .433) = 0.449$

$Q_i = EQ = (0.449)(13.881 \text{ cfs}) = 6.231$ cfs (EQ 12, HEC 12)

$Q_b = Q - Q_i = 13.881 - 6.231 = 7.650$ cfs

SVERDRUP

JOB TOYOTA 40477 SHEET NO. 30 OF 49

COMPUTATIONS FOR N.E. TRACK DRAIN DATE 8/91

BY BSW CHKD RTT

MAXIMUM CATCH BASIN SPACING. w/o SLOTTED DRAIN

$Q = CiA$ $i = 8.3$ IN/HR (SEE STEEP GRADES)

$C = 0.95$ (PAVEMENT)

PAVED AREA WIDTH = 60 + 1.5 = 61.5 FT

$= 0.40$ (EARTH CUT SLOPES)

MAX EARTH BASIN WIDTH = 41 FT.

$$Q = 6.231 \text{ cfs} = (8.3 \text{ IN/HR}) \left(\frac{(.95)(61.5) + (.40)(41)}{43,560} \right) L$$

$L = 437.04$ FT

USING 20 FT OF SLOTTED DRAIN:

CLOGGING ON GRADE

EFFECTIVE LENGTH w/ CLOGGING = $20(.67) = 13.33$ FT

$$L_T = 0.6\, Q^{0.42} S^{0.3} \left(\frac{1}{n S_e} \right)^{0.6} \quad \text{(EQ 16, HEC 12)}$$

$Q = 13.881$ cfs $n = 0.016$

$S = 0.0065$ FT/FT

(EQ 15, HEC 12) $S_e = S_x + S_w' E_o$ $S_w' = 0.066 - .025 = .042$

$S_e = 0.025 + (.042)(.433) = .043$

SVERDRUP

JOB TOYOTA 40477 SHEET NO. 31 OF 49

DATE 8/91

COMPUTATIONS FOR N.E. TRACK DRAIN BY BSW CHKD RVT

$$L_T = 0.6\,(13.881)^{0.42}(.0065)^{0.3}\left(\frac{1}{(.016)(.043)}\right)^{0.6}$$

$$= 31.57 \text{ FT}$$

$$L/L_T = 13.33 \text{ FT} / 31.57 \text{ FT} = .422$$

$$E = 1-(1-L/L_T)^{1.8} \qquad \text{(EQ 14, HEC 12)}$$

$$= 1-(1-.422)^{1.8} = 0.627$$

$$Q_i = (.627)(13.881 \text{ cfs}) = 8.710 \text{ cfs}$$

$$Q_b = 13.881 - 8.710 = 5.171 \text{ cfs}$$

FOR THE CATCH BASIN:

$Q = 5.171$ cfs FROM THE COMPUTER SPREAD SHT:

AT $Q = 5.161$ cfs, $T = 11.92$ FT DEPTH @ GUTTER = .401 FT

$$V = Q/A = 5.16 / 1.833 = 2.82 \text{ FT/SEC}$$

$$E_o = Q_w/Q = (Q_1+Q_2-Q_3'-Q_1')/(Q_2-Q_3+Q_4-Q_5+Q_6+Q_1$$

$$= (.740+3.701-1.260-.006)/(.740+3.701-.884+1.473-.130+.26)$$

$$= .615$$

ALL #'S OBTAINED FROM COMPUTER.

(SHOWN FOR INFO & CALC PURPOSES.

SVERDRUP

JOB TOYOTA 40477 SHEET NO. 32 OF 49

COMPUTATIONS FOR N.E. TRACK DRAIN DATE 8/91

BY RMW CHKD RJT

DEPTH = .401
SPREAD = 11.92
| 3.5 | 3.5 | 4.92 |

R_F (CHART 7, HEC 12) = 1.0

R_S (CHART 8, HEC 12)

$L = 1.5$ FT (3 FT W/ 50% CLOGGING) $\quad S_x = \dfrac{3.5(.04)+(.02)(4.92)}{3.5+4.92} = 0.028$

$R_S = 0.05$

$V_G = \dfrac{Q_2 - Q_3}{A_2 - A_3} = \dfrac{3.701 - .884}{1.206 - .412} = 3.54$ 1/SEC

$E = R_F E_o + R_S (1 - E_o)$

$= 1(.615) + .05(1 - .615) = 0.634$

$Q_i = (.634)(5.161) = 3.272$ cfs

$Q_b = 5.161 - 3.272 = 1.889$ cfs

WITH 20 L.F OF SLOTTED DRAIN:

$Q = Q_{SD} + Q_G = 8.710 + 3.272 = 11.982$ cfs

$Q = CiA = 11.982 = (8.3\ ^{IN}/_{HR}) \left(\dfrac{(.95)(61.5)+(.4)(41)}{43,560} \right) L$

$L = 840.41$ FT

DESIGN CATCH BASIN WITH MAX ADOT SPACING ≤ 840 FT WITH 20 L.F OF SLOTTED DRAIN.

SVERDRUP

JOB TOYOTA 40477 SHEET NO. 33 OF 49

COMPUTATIONS FOR N.E. TRACK DRAIN DATE 8/91 BY BMW CHKD RVT

ASSUME 1ST CATCH BASIN IS REQUIRED 1000 FT AFTER CUT BEGINS

DRAINAGE BASIN BEGINS STA 365+00

CHECK SPREAD @ STA 375+00 (STA 365 - 375)

AVG. WIDTH OF SLOPES

$$Q = CiA = (8.3\ IN/HR)(1000')\left(\frac{(.95)(61.5)+(1.40)(14.5')}{43,560}\right)$$

$$= 12.24\ cfs$$

SLOPE @ STA 375+00 = 0.0038 1/FT

Q (AT MAXIMUM SPREAD) = 10.61 cfs < 12.24

TRY 700 FT SPACE

$$Q = CiA = (8.3)(700)\left(\frac{(.95)(61.5)+(1.4)(12.5)}{43,560}\right)$$

AVG WIDTH BETWEEN 365 TO 372

$$= 8.46\ cfs$$

SLOPE @ STA 372+00 = 0.0027 1/FT

Q (MAXIMUM SPREAD) = 8.947 cfs

START CATCH BASINS @ STA 372+00

CHECK Qi @ THIS STATION TO DETERMINE NEXT C.B. STA.

SVERDRUP

JOB TOYOTA 40477 SHEET NO. 34 OF 49

COMPUTATIONS FOR N.E. TRACK DRAIN DATE 8/91 BY BSW CHKD RJT

@ STA 372+00 (VALUES NOT CALCULATED ARE FROM COMPUTER MODEL)

$S = 0.0027$ FT/FT $\qquad S_x = \frac{3.5(.04) + (11.5)(.02)}{15}$

$Q \cong 8.5$ cfs $\qquad = 0.025$

$T = 19.2$ FT $\qquad E_o = .441$

DEPTH @ GUTTER = 0.538 FT $\qquad V = Q/A = 8.5/3.963 = 2.15$ FT/SEC

$$L_T = 0.6\, Q^{0.42}\, S^{0.3} \left(\frac{1}{n\, S_e}\right)^{0.6}$$

$S_e = S_x + S_w E_o \qquad S_w' = .06 - .025 = .042$

$= (0.025) + (.042)(.441) = 0.043$

$$L_T = (0.6)(8.5)^{0.42}(.0027)^{.3}\left(\frac{1}{(.016)(.043)}\right)^{.6} = 19.64 \text{ FT}$$

$L = (20\text{FT SLOTTED DRAIN})(67\%\text{ CLOG.}) = 13.33$ FT

$L/L_T = 13.33/19.64 = .679$

$E = 1-(1-L/L_T)^{1.8} = 1-(1-.679)^{1.8} = .871$

$Q_{i_{S.D}} = (.871)(8.5) = 7.399$ cfs

$Q_b = Q_{(GRATE)} = 8.5 - 7.399 = 1.101$ cfs

SVERDRUP

JOB TOYOTA 4077 SHEET NO. 35 OF 49

COMPUTATIONS FOR N.E. TRACK DRAIN. DATE 8/91

BY BSW CHKD ROT

$Q_{(GRATE)} = 1.101$ cfs $\quad E_o = .818$

$T = 6.048$ FT $\quad S_x = 0.04$

DEPTH = .275 FT $\quad V = Q/A = 1.101 / .742 = 1.48$ FT/SEC

$Y_{GUTTER} = \frac{Q_2 - Q_3}{A_2 - A_3} = \frac{(.877 - .074)}{(.569 - .089)} = 1.67$ FT/S.

$R_F = 1.0$ (CHART 7, HEC 12)

$R_S = .25$ (CHART 8, HEC 12) $\quad L = 1.5'$ $S_x = 0.04$

↑ 3FT w/ 50% CLOG.

$E = R_F E_o + R_S (1 - E_o)$

$= (1.0)(.818) + .25(1 - .818) = 0.864$

$Q_i = EQ = (.864)(1.101) = .951$ cfs

$Q_i = 7.399 + .951 = 8.350$ cfs

$Q_b = 8.5 - 8.35 = .15$ cfs $\quad$ OK

SEE FOLLOWING CALC. SHEET FOR BALANCE OF CATCH BASIN CAPACITIES.

CATCH BASIN DESIGN: CATCH BASIN CALCULATION SHEET

LOCATION DATA

HIGHWAY: TOYOTA, USA TEST TRACK

LOCATION: N/E TRACK SECTION, LOW GUTTER

PROJECT NO.: 40477

LOCATION			DRAINAGE AREA			I	Q	Q c	Qt	So	SLOTTED DRAIN			GRATED INLET		
CB NO.	FROM	TO	Length ft.	W ft.	CA Acres	IN/HR	CFS	CFS	CFS	ft/ft	T ft	L ft.	Qb CFS	T ft.	V FPS	Qb CFS
	365+00	372+00	700	13	1.022	8.3	8.48	0.00	8.48	0.0027	19.1	20	0.54	4.3	1.33	0.03
R1	372+00	375+30	330	19	0.500	8.3	4.15	0.03	4.18	0.0038	12.2	10	1.00	5.3	1.82	0.11
R2	375+30	378+60	330	19	0.500	8.3	4.15	0.11	4.26	0.0048	11.6	10	1.16	5.4	2.06	0.13
R3	378+60	381+90	330	18	0.497	8.3	4.12	0.13	4.26	0.0056	11.1	10	1.23	5.4	2.22	0.14
R4	381+90	385+20	330	17	0.494	8.3	4.10	0.14	4.24	0.0061	10.8	10	1.28	5.3	2.31	0.15
R5	385+20	388+50	330	19	0.500	8.3	4.15	0.15	4.30	0.0064	10.7	10	1.32	5.4	2.37	0.16
R6	388+50	391+80	330	22	0.509	8.3	4.23	0.16	4.38	0.0065	10.8	10	1.37	5.4	2.41	0.17
R7	391+80	395+10	330	27	0.524	8.3	4.35	0.17	4.52	0.0065	11.0	10	1.46	5.6	2.46	0.19
R8	395+10	398+40	330	32	0.539	8.3	4.48	0.19	4.67	0.0065	11.2	10	1.57	5.8	2.52	0.22
R9	398+40	401+70	330	36	0.552	8.3	4.58	0.22	4.80	0.0065	11.3	10	1.62	5.9	2.54	0.24
R10	401+70	405+00	330	38	0.558	8.3	4.63	0.24	4.87	0.0065	11.5	10	1.69	6.0	2.57	0.26
R11	405+00	408+30	330	36	0.552	8.3	4.58	0.26	4.84	0.0065	11.4	10	1.67	5.9	2.56	0.26
R12	408+30	412+70	440	40	0.752	8.3	6.24	0.26	6.49	0.0065	13.5	20	0.53	3.3	1.80	0.01
R13	412+70	417+10	440	41	0.756	8.3	6.27	0.01	6.28	0.0065	13.3	20	0.48	3.1	1.75	0.01
R14	417+10	421+50	440	38	0.743	8.3	6.17	0.01	6.18	0.0065	13.1	20	0.43	3.0	1.70	0.00
R15	421+50	425+90	440	33	0.723	8.3	6.00	0.00	6.00	0.0065	12.9	20	0.38	2.8	1.65	0.00
R16	425+90	430+30	440	30	0.711	8.3	5.90	0.00	5.90	0.0065	12.8	20	0.34	2.7	1.60	0.00
R17	430+30	434+70	440	27	0.699	8.3	5.80	0.00	5.80	0.0065	12.7	20	0.32	2.7	1.59	0.00
R18	434+70	439+10	440	22	0.679	8.3	5.63	0.00	5.63	0.0065	12.5	20	0.28	2.5	1.52	0.00
R19	439+10	443+50	440	15	0.651	8.3	5.40	0.00	5.40	0.0065	12.2	20	0.21	2.3	1.42	0.00
R20	443+50	447+90	440	11	0.634	8.3	5.27	0.00	5.27	0.0065	12.0	20	0.18	2.1	1.37	0.00
R21	447+90	452+30	440	8	0.622	8.3	5.16	0.00	5.16	0.0065	11.9	20	0.15	2.0	1.31	0.00
R22	452+30	456+70	440	8	0.622	8.3	5.16	0.00	5.16	0.0065	11.9	20	0.15	2.0	1.31	0.00
R23	456+70	461+10	440	7	0.618	8.3	5.13	0.00	5.13	0.0065	11.8	20	0.15	2.0	1.30	0.00
R24	461+10	464+50	340	4	0.468	8.3	3.89	0.00	3.89	0.0065	10.0	20	0.00	0.1	0.23	0.00

R25 464+50 OUTFALL 0

CATCH BASIN DESIGN: CATCH BASIN CALCULATION SHEET

LOCATION DATA

HIGHWAY: TOYOTA, USA TEST TRACK

LOCATION: N/E TRACK SECTION, LOW GUTTER

PROJECT NO.: 40477

LOCATION			DRAINAGE AREA			I	Q	Q c	Qt	So	SLOTTED DRAIN			GRATED INLET		
CB NO.	FROM	TO	Length ft.	W ft.	CA Acres	IN/HR	CFS	CFS	CFS	ft/ft	T ft	L ft.	Qb CFS	T ft.	V FPS	Qb CFS
	365+00	372+00	700	13	1.022	8.3	8.48	0.00	8.48	0.0027	19.1	20	0.54	4.3	1.33	0.03
R1	372+00	375+30	330	19	0.500	8.3	4.15	0.03	4.18	0.0038	12.2	0	4.13	12.2	2.74	1.49
R2	375+30	378+60	330	19	0.500	8.3	4.15	1.49	5.64	0.0048	13.6	0	5.60	13.5	3.23	2.24
R3	378+60	381+90	330	18	0.497	8.3	4.12	2.24	6.37	0.0056	13.9	0	6.32	13.8	3.53	2.60
R4	381+90	385+20	330	17	0.494	8.3	4.10	2.60	6.70	0.0061	13.9	0	6.64	13.9	3.69	2.75
R5	385+20	388+50	330	19	0.500	8.3	4.15	2.75	6.90	0.0064	14.0	0	6.85	13.9	3.79	2.85
R6	388+50	391+80	330	22	0.509	8.3	4.23	2.85	7.08	0.0065	14.1	0	7.05	14.1	3.84	2.97
R7	391+80	395+10	330	27	0.524	8.3	4.35	2.97	7.32	0.0065	14.4	0	7.31	14.4	3.87	3.12
R8	395+10	398+40	330	32	0.539	8.3	4.48	3.12	7.60	0.0065	14.6	0	7.52	14.6	3.90	3.25
R9	398+40	401+70	330	36	0.552	8.3	4.58	3.25	7.83	0.0065	14.8	0	7.73	14.8	3.92	3.39
R10	401+70	405+00	330	38	0.558	8.3	4.63	3.39	8.01	0.0065	15.1	0	8.01	15.0	3.96	3.56
R11	405+00	408+30	330	36	0.552	8.3	4.58	3.56	8.13	0.0065	15.2	0	8.06	15.1	3.97	3.59
R12	408+30	412+70	440	40	0.752	8.3	6.24	3.59	9.83	0.0065	16.6	0	9.73	16.6	4.15	4.67
R13	412+70	417+10	440	41	0.756	8.3	6.27	4.67	10.94	0.0065	17.6	0	10.93	17.5	4.27	5.46
R14	417+10	421+50	440	38	0.743	8.3	6.17	5.46	11.63	0.0065	18.0	0	11.50	18.0	4.33	5.84
R15	421+50	425+90	440	33	0.723	8.3	6.00	5.84	11.84	0.0065	18.2	0	11.71	18.1	4.35	5.99
R16	425+90	430+30	440	30	0.711	8.3	5.90	5.99	11.89	0.0065	18.2	0	11.79	18.2	4.35	6.04
R17	430+30	434+70	440	27	0.699	8.3	5.80	6.04	11.84	0.0065	18.2	0	11.71	18.1	4.35	5.99
R18	434+70	439+10	440	22	0.679	8.3	5.63	5.99	11.62	0.0065	18.0	0	11.50	18.0	4.33	5.84
R19	439+10	443+50	440	15	0.651	8.3	5.40	5.84	11.24	0.0065	17.7	0	11.14	17.7	4.29	5.60
R20	443+50	447+90	440	11	0.634	8.3	5.27	5.60	10.86	0.0065	17.5	0	10.79	17.4	4.26	5.37
R21	447+90	452+30	440	8	0.622	8.3	5.16	5.37	10.53	0.0065	17.3	0	10.52	17.2	4.23	5.19
R22	452+30	456+70	440	8	0.622	8.3	5.16	5.19	10.35	0.0065	17.1	0	10.32	17.1	4.21	5.05
R23	456+70	461+10	440	7	0.618	8.3	5.13	5.05	10.18	0.0065	16.9	20	2.11	6.6	2.75	0.40
R24	461+10	464+50	340	4	0.468	8.3	3.89	0.40	4.29	0.0065	10.6	20	0.01	0.8	0.70	0.00
R25	464+50	OUTFALL														

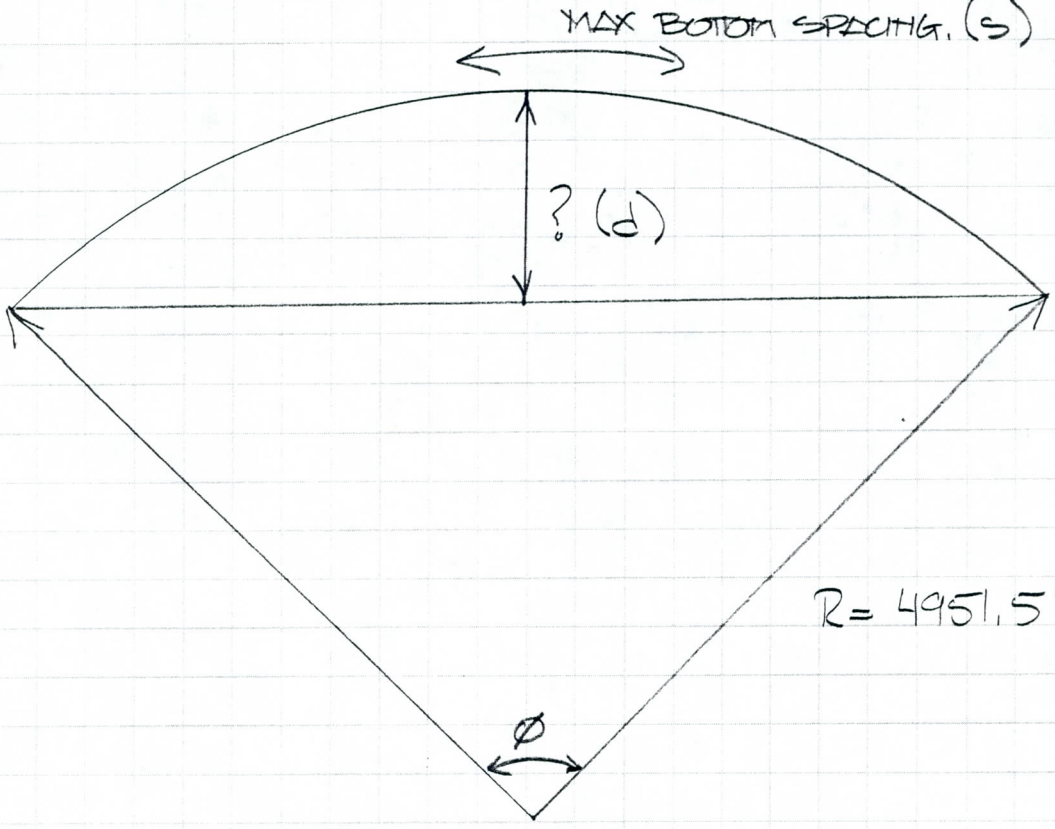
SVERDRUP

JOB TOYOTA 40477 SHEET NO. 38 OF 49

DATE 8/91

COMPUTATIONS FOR N.E. TRACK DRAIN BY BSW CHKD RJT

CHECK OFFSET FOR 330 FT SPACING:



THE OFFSET RESULTING FROM THE BOTTOM CATCH BASIN SPACING IS:

SPACING (S) =

$$\phi = \frac{S}{r} = \frac{(330)}{4951.5} \times \frac{360^\circ}{2\pi \text{ RAD.}} = 3.818^\circ$$

$$3.818^\circ = 2\left(\text{ARC COS}\left(\frac{r-d}{r}\right)\right)$$

$$\frac{r-d}{r} = \cos\left(\frac{(3.818)}{2}\right) = .999$$

$$\text{OFFSET} = d = 4951.5 - (4951.5)(.999) = 2.75^{\text{FT}}$$

SVERDRUP

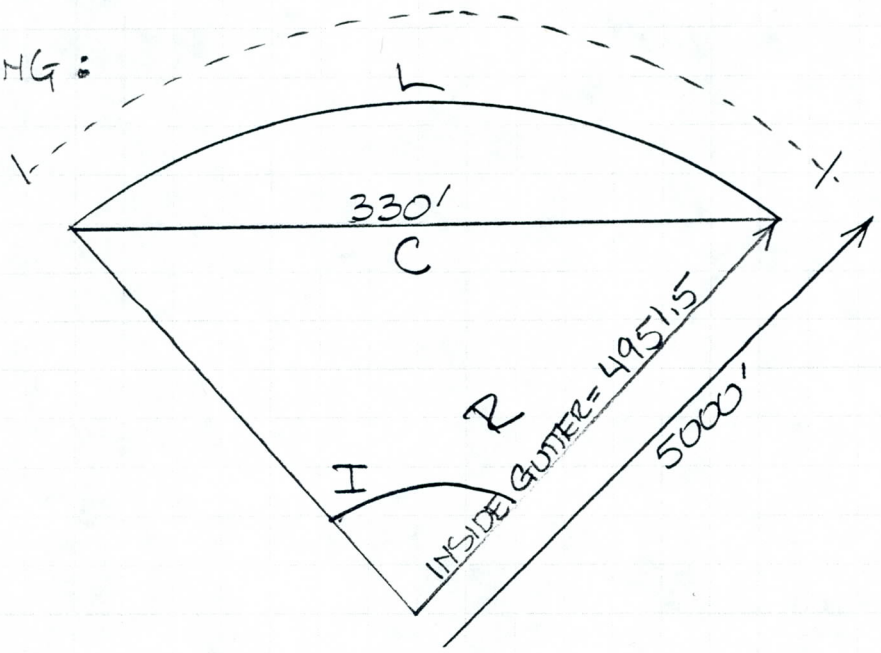
JOB TOYOTA 40477 SHEET NO. 39 OF 49

COMPUTATIONS FOR HIE. TRACK DRAIN DATE 8/91

BY BSW CHKD RJT

INSIDE GUTTER

STATIONING:



FOR 330' SPACING:

$$C = 330^{FT} = 2R(\sin \tfrac{1}{2} I)$$

$$= 2(4951.5)\left(\sin \frac{I}{2}\right)$$

$$I = 3.8192^\circ$$

$$L = R(I_{(RADIANS)})$$

$$= (5000^{FT})(3.8192)\left(\frac{2\pi}{360}\right) = \underline{333.294 \text{ FT}} \text{ STATIONS}$$

FOR 330 FT STATIONING:

$$L = R(I) = 330 = (5000)(I)\frac{2\pi}{360} \Rightarrow I = 3.781^\circ$$

$$C = 2R \sin(\tfrac{1}{2} I) = 2(4951.5)\sin\left(\frac{3.781}{2}\right) = 326.74^{FT}$$

SVERDRUP

JOB TOYOTA 40477 SHEET NO. 40 OF

DATE 8/91

COMPUTATIONS FOR N.E. TRACK DRAIN BY [illegible] CHKD RTT

FOR 440 FT STATIONING FOR INSIDE GUTTER:

$$L = R(I) \Rightarrow 440 = (5000)(I)\left(\frac{2\pi}{360}\right)$$

$$I = 5.042^\circ$$

$$C = 2R \sin(\tfrac{1}{2}I)$$

$$= 2(4951.5)\sin\left(\frac{5.042}{2}\right) = 435.59$$

FOR 350 FT STATIONS

$$L = 350 = (5000)(I)\left(\frac{2\pi}{360}\right) \Rightarrow I = 4.01$$

$$C = 2(49515)\sin\left(\frac{4.01}{2}\right) = 346.53 \text{ FT}$$

FOR 400 FT STATIONS

$$L = 400 = (5000)(I)\left(\frac{2\pi}{360}\right) \Rightarrow I = 4.583^\circ$$

$$C = 2(4951.5)\sin\left(\frac{4.583}{2}\right) = 396.01$$

FOR 425 FT STATIONS

$$L = 425 = (5000)(I)\left(\frac{2\pi}{360}\right) \Rightarrow I = 4.87^\circ$$

$$C = 2(4951.5)\sin\left(\frac{4.87}{2}\right) = 420.75$$

SVERDRUP

JOB TOYOTA 40477 SHEET NO. 41 OF 49

DATE 8/91

COMPUTATIONS FOR H.E. TRACK DRAIN. BY BGW CHKD RJT

FOR LOW GUTTER SEWER DESIGN, SEE

SAMPLE CALCS FOR "HIGH GUTTER"

IN CONJUNCTION WITH THE FOLLOWING CALCULATION

SHEETS & THE FOLLOWING MODIFICATIONS:

FOR T_c, L = 330.03FT = .0626 MILE

$$\text{AREA} = \frac{330(61.5 + 40)}{43{,}560} = .769 \text{ ACRES}$$

$$\text{SLOPE} = \frac{16'}{.0626 \text{ MILE}} = 255.6 \text{ FT/MILE}$$

T_c = 3.7 MIN

PAVED AREA = 61.5 FT x L

L = MANHOLE / CATCH BASIN SPACE.

THE CALC. SHEETS ARE SIMILAR FOR HIGH & LOW GUTTER. ONLY THE ABOVE LISTED VARIABLES CHANGE.

* SEE ALSO PAGE 3

STORM SEWER DESIGN: SEWER CALCULATION SHEET

LOCATION DATA

HIGHWAY: TOYOTA, USA TEST TRACK

LOCATION: N/E TRACK SECTION, LOW GUTTER

PROJECT NO.: 40477

DESIGN DATA

FREQUENCY: 50 (YEAR)

LOCATION			DRAINAGE AREA			TIME OF FLOW (MIN.)			I	Q	SEWER PROFILE				SEWER DESIGN					
LINE NO.	FROM	TO	NO.	INCREM. CA	Σ CA	INLET	SEWER	DESIGN	(in/hr)	(CFS)	INV. ELEVATION INLET	INV. ELEVATION OUTLET	LENGTH (ft)	SLOPE (ft/ft)	DIAM. (in)	n	Q FULL (CFS)	V FULL (FPS)	V ACT. (FPS)	FLOW (MIN.)
	365+00	372+00	: LIMITS OF INITIAL DRAINAGE INTO SYSTEM																	
R1	372+00	375+30		1.022	1.022	3.7		5.0	8.4	9	1731.10	1730.09	326.74	0.0031	24	0.010	16	5.2	5.3	1.0
R2	375+30	378+60		0.500	1.522	3.7	1.0	5.0	8.4	13	1729.98	1728.69	326.74	0.0040	24	0.010	19	5.9	6.5	0.8
R3	378+60	381+90		0.498	2.021	3.7	0.8	5.6	8.0	16	1728.57	1727.02	326.74	0.0048	24	0.010	20	6.5	7.3	0.7
R4	381+90	385+20		0.495	2.516	3.7	0.7	6.3	7.7	19	1726.90	1725.12	326.74	0.0055	24	0.010	22	6.9	7.9	0.7
R5	385+20	388+50		0.494	3.010	3.7	0.7	7.0	7.4	22	1725.01	1723.06	326.74	0.0060	24	0.010	23	7.3	8.4	0.6
R6	388+50	391+80		0.500	3.510	3.7	0.6	7.7	7.2	25	1722.44	1720.44	326.74	0.0062	30	0.010	42	8.6	8.9	0.6
R7	391+80	395+10		0.508	4.017	3.7	0.6	8.3	6.9	28	1720.32	1718.28	326.74	0.0063	30	0.010	42	8.6	9.4	0.6
R8	395+10	398+40		0.523	4.540	3.7	0.6	8.8	6.7	31	1718.16	1716.12	326.74	0.0063	30	0.010	42	8.6	9.5	0.6
R9	398+40	401+70		0.538	5.078	3.7	0.6	9.4	6.6	33	1716.00	1714.00	326.74	0.0062	30	0.010	42	8.6	9.6	0.6
R10	401+70	405+00		0.552	5.630	3.7	0.6	10.0	6.5	37	1713.88	1711.87	326.74	0.0062	30	0.010	42	8.6	9.8	0.6
R11	405+00	408+30		0.558	6.187	3.7	0.6	10.5	6.3	39	1711.75	1709.74	326.74	0.0062	30	0.010	42	8.6	9.8	0.6
R12	408+30	412+70		0.552	6.739	3.7	0.6	11.1	6.2	42	1709.12	1706.36	435.59	0.0064	36	0.010	69	9.8	10.5	0.7
R13	412+70	417+10		0.596	7.335	3.7	0.7	11.8	6.0	44	1706.24	1703.47	435.59	0.0064	36	0.010	69	9.8	10.5	0.7
R14	417+10	421+50		0.754	8.088	3.7	0.7	12.5	5.9	48	1703.35	1700.62	435.59	0.0063	36	0.010	69	9.7	10.6	0.7
R15	421+50	425+90		0.743	8.832	3.7	0.7	13.2	5.8	51	1700.50	1697.78	435.59	0.0063	36	0.010	69	9.7	10.7	0.7
R16	425+90	430+30		0.723	9.555	3.7	0.7	13.8	5.6	54	1697.66	1694.94	435.59	0.0063	36	0.010	69	9.7	10.9	0.7
R17	430+30	434+70		0.711	10.266	3.7	0.7	14.5	5.6	57	1694.82	1692.09	435.59	0.0063	36	0.010	69	9.7	11.0	0.7
R18	434+70	439+10		0.699	10.965	3.7	0.7	15.2	5.5	60	1691.97	1689.25	435.59	0.0063	36	0.010	69	9.7	11.1	0.7
R19	439+10	443+50		0.677	11.642	3.7	0.7	15.8	5.4	63	1689.13	1686.40	435.59	0.0063	36	0.010	69	9.7	11.2	0.6
R20	443+50	447+90		0.651	12.292	3.7	0.6	16.5	5.3	66	1686.28	1683.52	435.59	0.0064	36	0.010	69	9.8	11.3	0.6
R21	447+90	452+30		0.632	12.925	3.7	0.6	17.1	5.2	67	1683.40	1680.67	435.59	0.0063	36	0.010	69	9.7	11.3	0.6
R22	452+30	456+70		0.620	13.545	3.7	0.6	17.8	5.0	68	1680.55	1677.83	435.59	0.0063	36	0.010	69	9.7	11.3	0.6
R23	456+70	461+10		0.620	14.165	3.7	0.6	18.4	4.9	70	1677.71	1674.98	435.59	0.0063	36	0.010	69	9.7	11.3	0.6
R24	461+10	464+50		0.616	14.781	3.7	0.6	19.0	4.8	71	1674.86	1672.76	336.64	0.0063	36	0.010	69	9.7	11.3	0.5
R25	464+50	465+70		0.467	15.248	3.7	0.5	19.5	4.8	72	1672.65	1672.12	135.00	0.0040	42	0.012	69	7.2	8.3	0.3
SD1	465+70	OUTFALL		0.000	15.248	3.7	0.3	19.8	4.8	72	1672.11	1672.11								

STORM SEWER DESIGN: ELEVATION SUMMARY

LOCATION DATA

HIGHWAY: TOYOTA, USA TEST TRACK

LOCATION: N/E TRACK SECTION, LOW GUTTER

PROJECT NO.: 40477

LOCATION			SEWER PROFILE						
LINE NO.	FROM	TO	INV. ELEVATION		GRATE ELEV.		LENGTH (FT.)	SLOPE (FT/FT)	DIAM. (IN.)
			INLET	OUTLET	INLET	OUTLET			
R1	372+00	375+30	1731.10	1730.09	1736.06	1735.02	326.74	0.0031	24
R2	375+30	378+60	1729.98	1728.69	1735.02	1733.63	326.74	0.0040	24
R3	378+60	381+90	1728.57	1727.02	1733.63	1731.95	326.74	0.0048	24
R4	381+90	385+20	1726.90	1725.12	1731.95	1730.04	326.74	0.0055	24
R5	385+20	388+50	1725.01	1723.06	1730.04	1727.99	326.74	0.0060	24
R6	388+50	391+80	1722.44	1720.44	1727.99	1725.86	326.74	0.0062	30
R7	391+80	395+10	1720.32	1718.28	1725.86	1723.72	326.74	0.0063	30
R8	395+10	398+40	1718.16	1716.12	1723.72	1721.58	326.74	0.0063	30
R9	398+40	401+70	1716.00	1714.00	1721.58	1719.44	326.74	0.0062	30
R10	401+70	405+00	1713.88	1711.87	1719.44	1717.30	326.74	0.0062	30
R11	405+00	408+30	1711.75	1709.74	1717.30	1715.16	326.74	0.0062	30
R12	408+30	412+70	1709.12	1706.36	1715.16	1712.31	435.59	0.0064	36
R13	412+70	417+10	1706.24	1703.47	1712.31	1709.45	435.59	0.0064	36
R14	417+10	421+50	1703.35	1700.62	1709.45	1706.60	435.59	0.0063	36
R15	421+50	425+90	1700.50	1697.78	1706.60	1703.74	435.59	0.0063	36
R16	425+90	430+30	1697.66	1694.94	1703.74	1700.89	435.59	0.0063	36
R17	430+30	434+70	1694.82	1692.09	1700.89	1698.03	435.59	0.0063	36
R18	434+70	439+10	1691.97	1689.25	1698.03	1695.18	435.59	0.0063	36
R19	439+10	443+50	1689.13	1686.40	1695.18	1692.32	435.59	0.0063	36
R20	443+50	447+90	1686.28	1683.52	1692.32	1689.47	435.59	0.0064	36
R21	447+90	452+30	1683.40	1680.67	1689.47	1686.62	435.59	0.0063	36
R22	452+30	456+70	1680.55	1677.83	1686.62	1683.76	435.59	0.0063	36
R23	456+70	461+10	1677.71	1674.98	1683.76	1680.91	435.59	0.0063	36
R24	461+10	464+50	1674.86	1672.76	1680.91	1678.70	336.64	0.0063	36
R25	464+50	465+70	1672.65	1672.12	1678.70		135.00	0.0040	42
SD1	465+70	OUTFALL	1672.01						

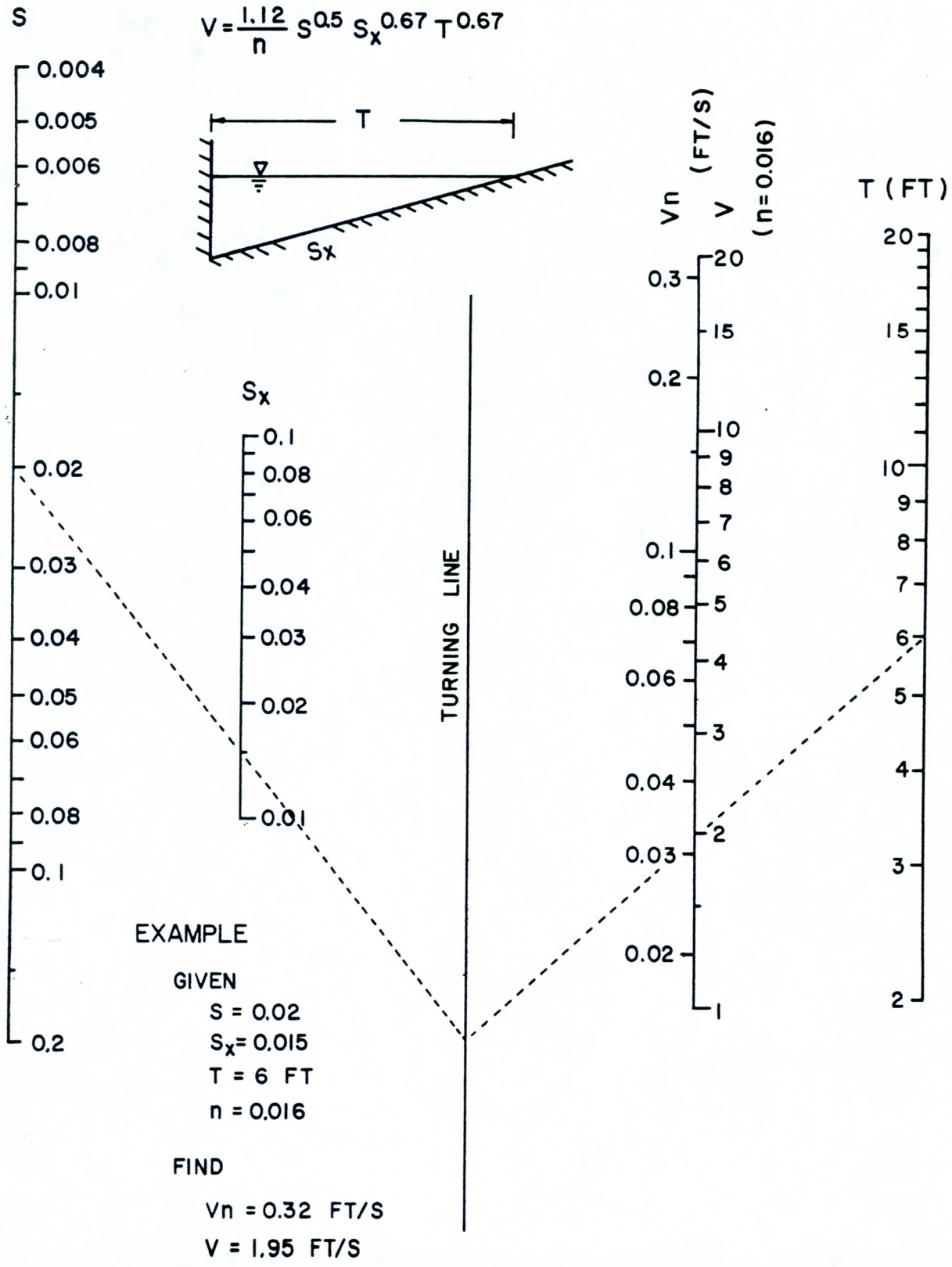
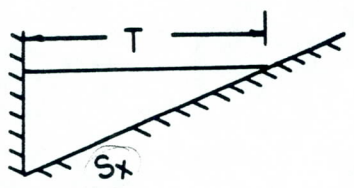


CHART 2. Velocity in triangular gutter sections.



$$Q = \frac{0.56}{n} S_x^{1.67} S^{0.5} T^{2.67}$$

EXAMPLE: GIVEN:

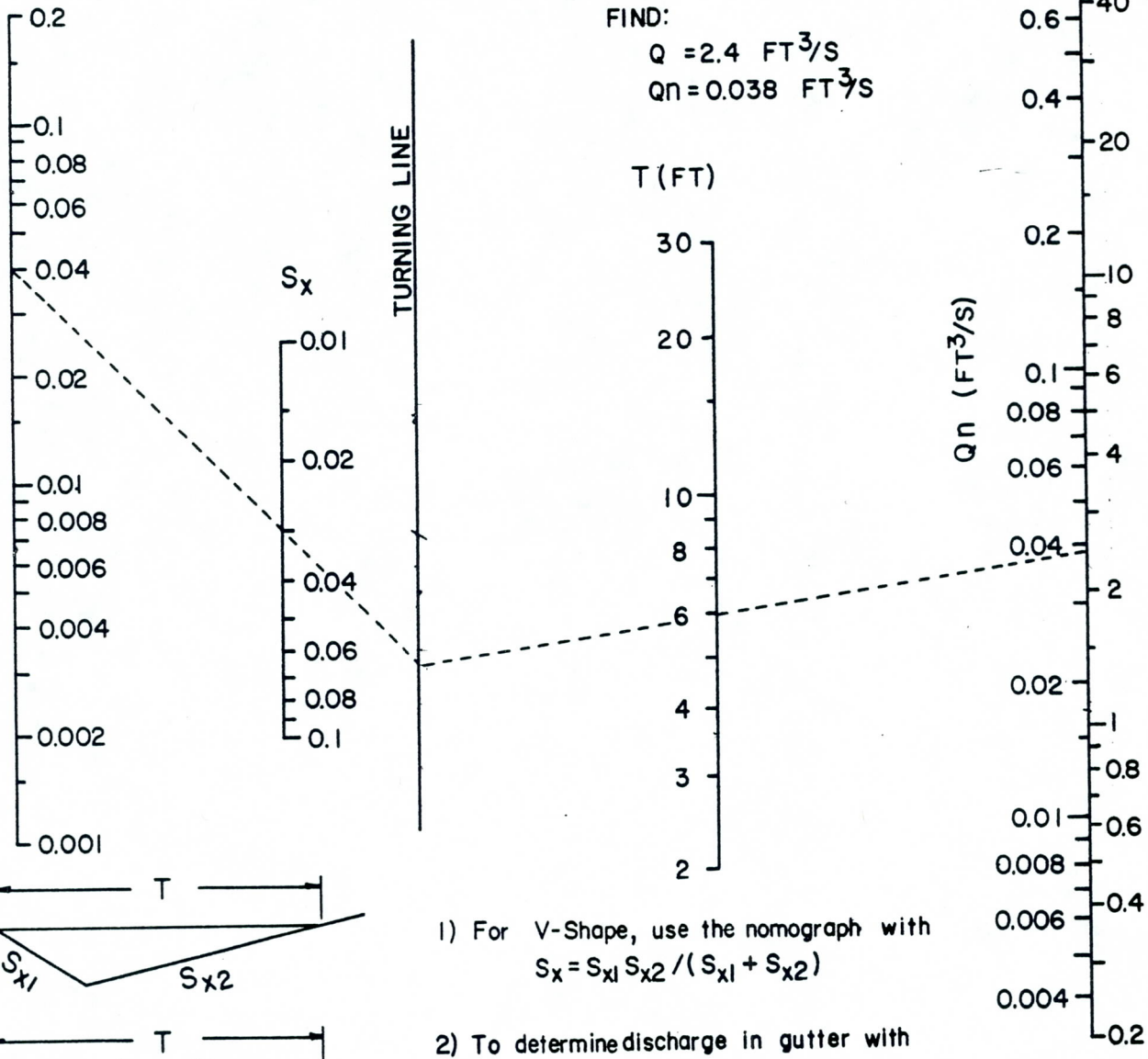
$n = 0.016$; $S_x = 0.03$

$S = 0.04$; $T = 6$ FT

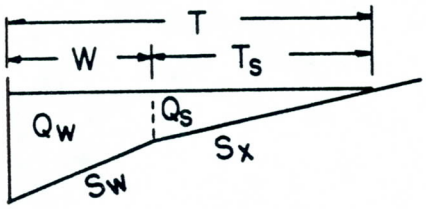
FIND:

$Q = 2.4$ FT^3/S

$Qn = 0.038$ FT^3/S



1) For V-Shape, use the nomograph with $S_x = S_{x1} S_{x2} / (S_{x1} + S_{x2})$



2) To determine discharge in gutter with composite cross slopes, find Q_s using T_s and S_x. Then, use CHART 4 to find E_o. The total discharge is $Q = Q_s/(1 - E_o)$, and $Q_w = Q - Q_s$.

CHART 3. Flow in triangular gutter sections.

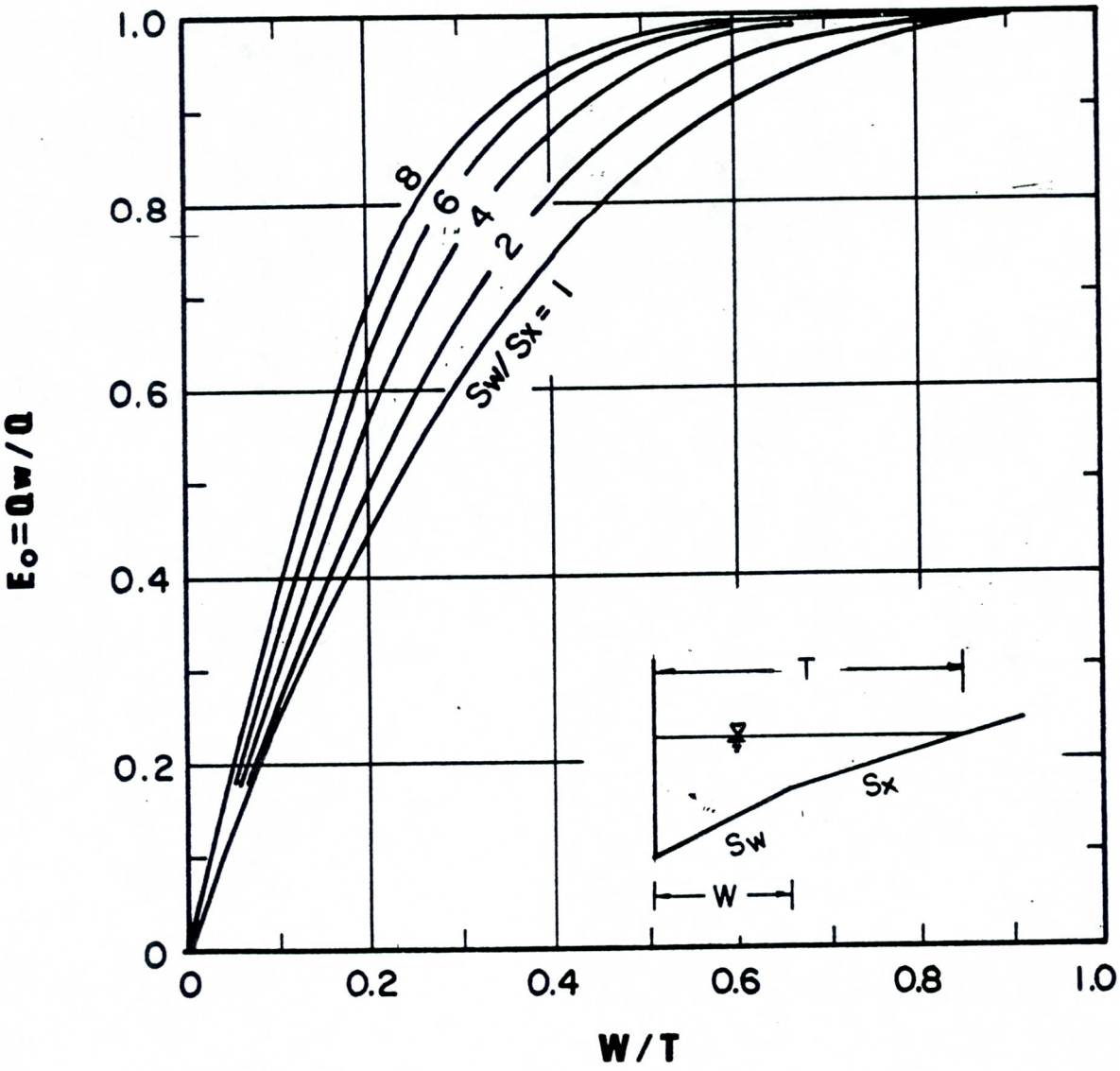


CHART 4. Ratio of frontal flow to total gutter flow.

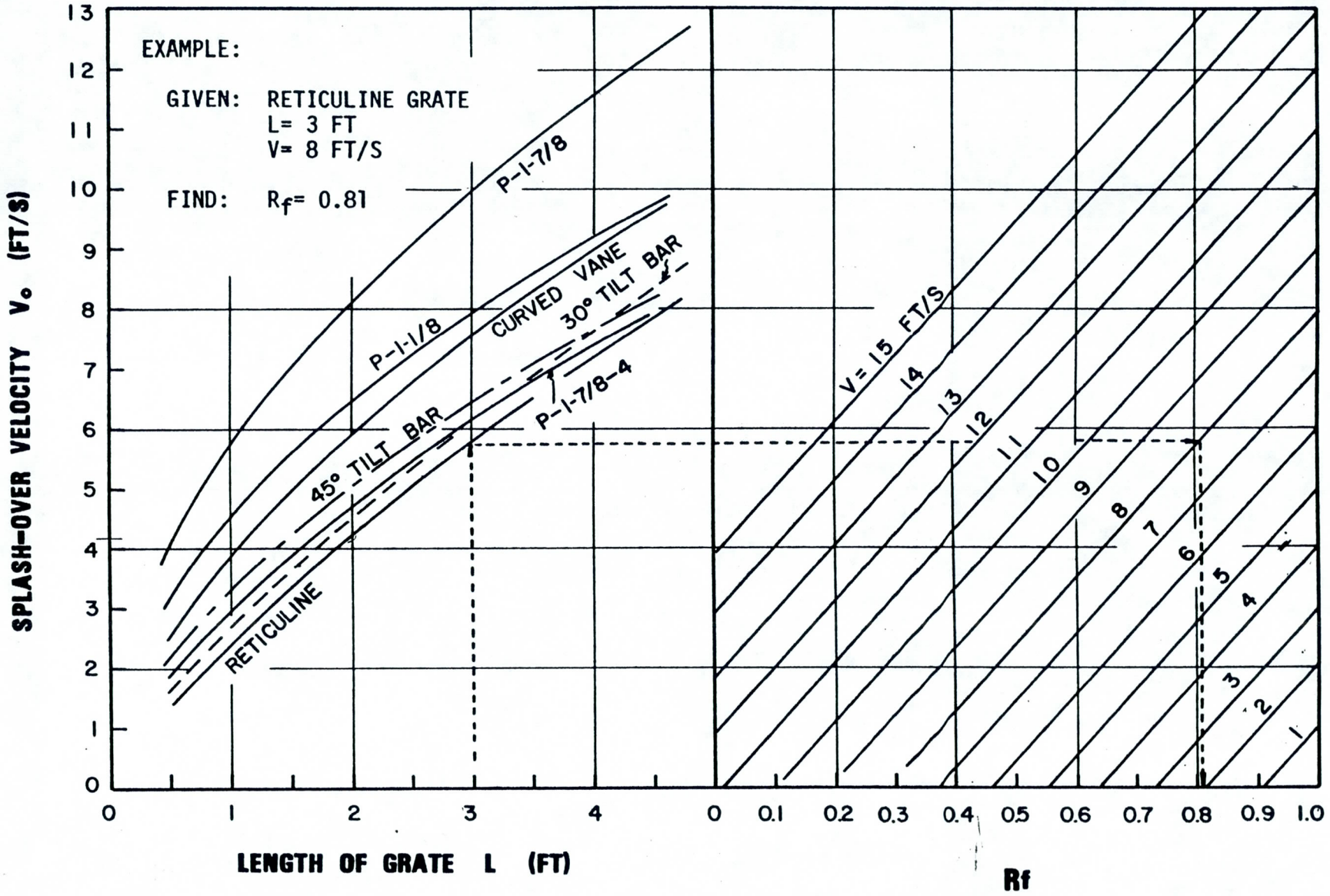


CHART 7. Grate inlet frontal flow interception efficiency.

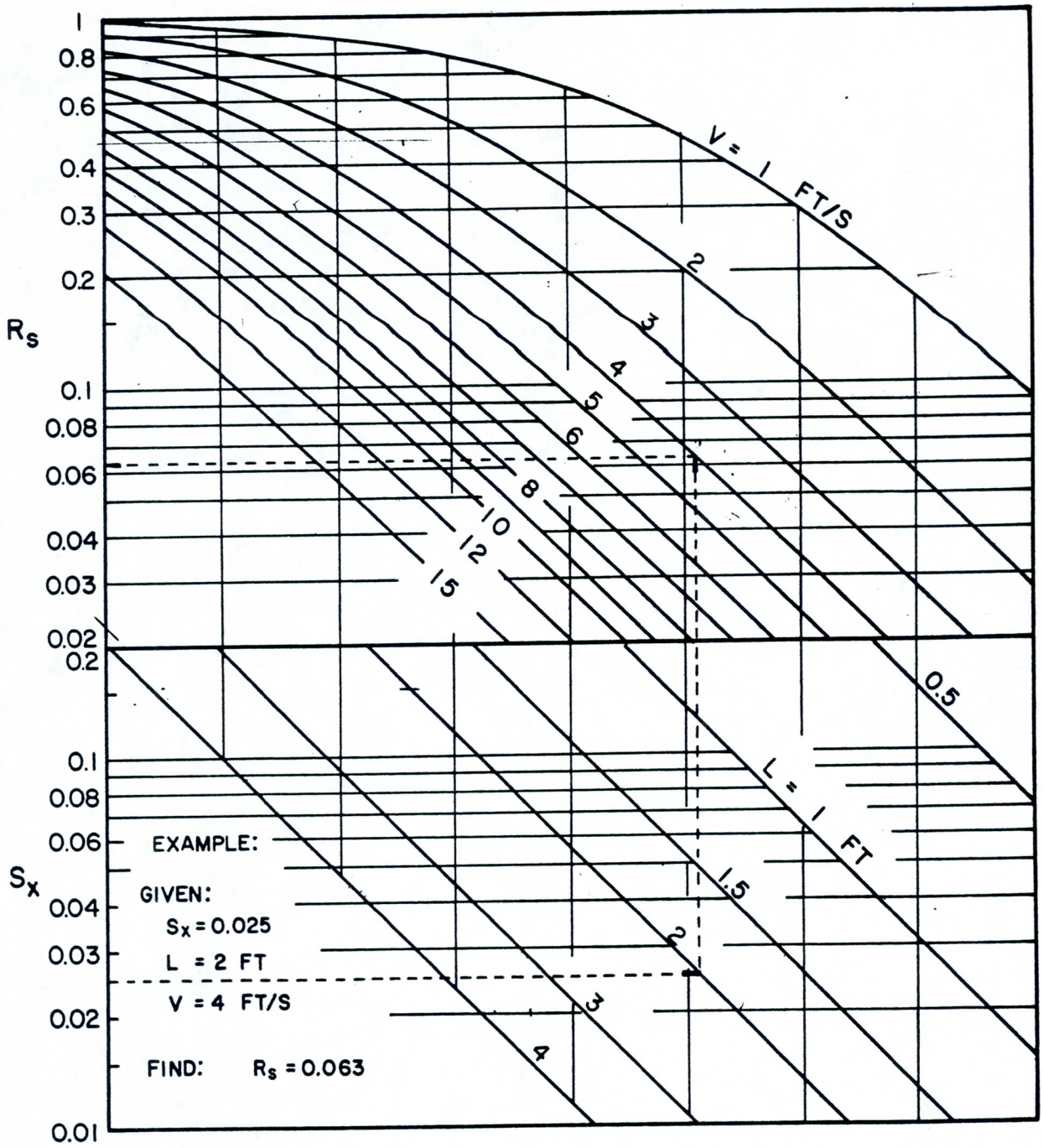


CHART 8. Grate inlet side flow interception efficiency.

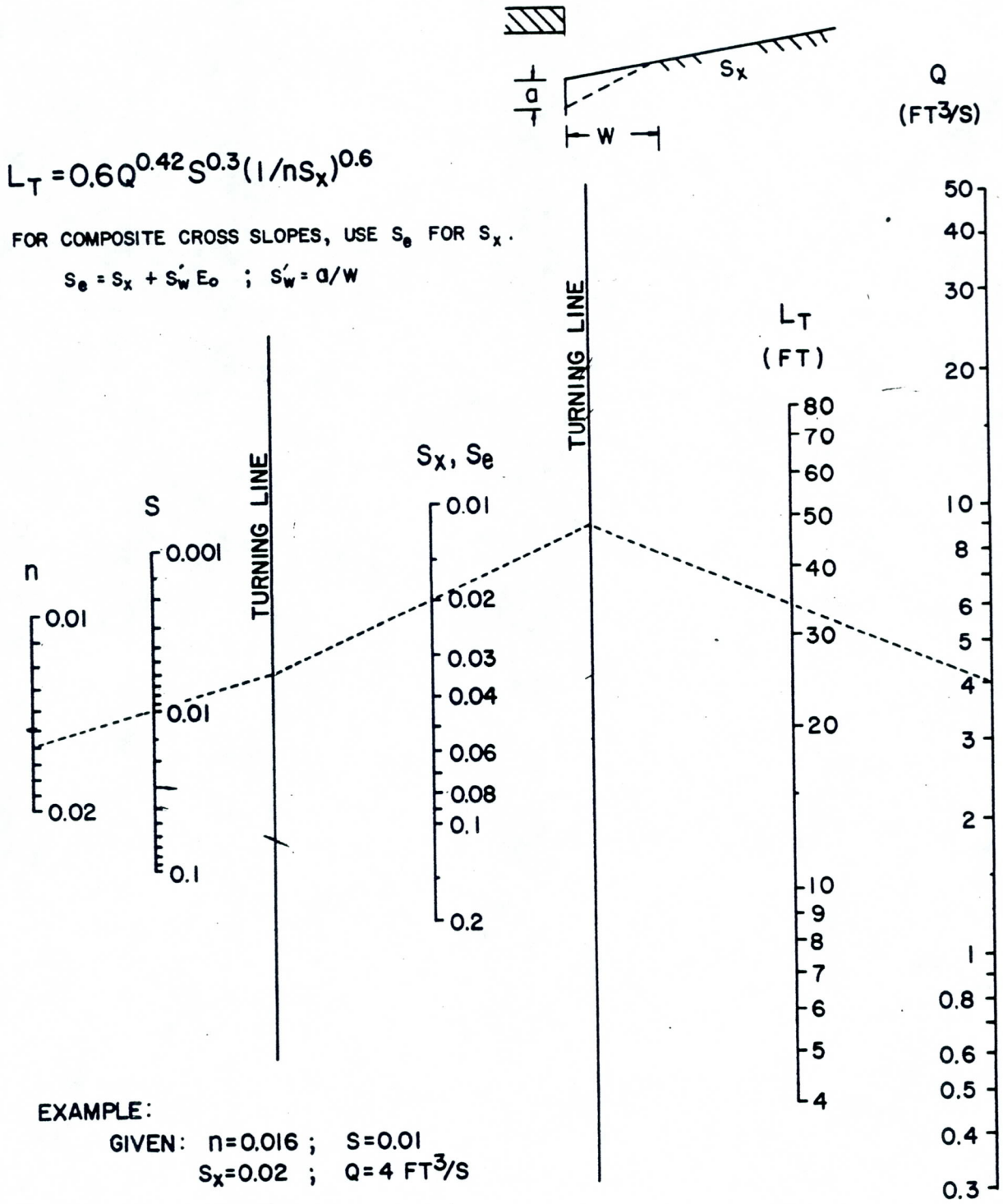


CHART 9. Curb-opening and slotted drain inlet length for total interception.

SVERDRUP

JOB TOYOTA 40477 SHEET NO. 1 OF 10

DATE 8/91

COMPUTATIONS FOR TRACK DRAIN OUTFALL BY BSW CHKD RJT
PLUNGE BASIN (P.B.)

STA 464+50, 48' RT
INV EL 1672.65

42 IN RCP
n=0.012, L=135 FT
S=0.0040 1/FT

STA 465+70
110' RT
OUTFALL EL
= 1672.11

FROM STORM SEWER PIPE CALC SUMMARY SHEET:

$Q = 72.5$ cfs

$$Q_{FULL} = \frac{1.486}{n} A \left(\frac{D}{4}\right)^{2/3} S^{1/2}$$

$n = 0.012$
$S = 0.004$ $D = 3.5$ FT

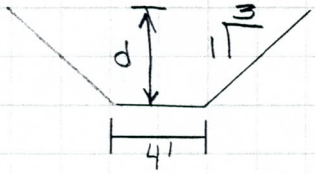
$Q_{FULL} = 68.93$ cfs $< Q_{OUTFALL}$

∴ PIPE FLOWS FULL, UNDER PRESSURE

CHECK IF INLET OR OUTLET CONTROLS.

42' RCP, L=135 S=0.004 n=0.012

TAILWATER:



$Q = 72.5$ cfs
$n = 0.03$
$S = 0.006$ 1/FT

TVV = $d = 1.84$ FT
$V = 4.14$ 1/SEC.

FOR OUTLET CONTROL: (USING HEC 5 MANUAL)

$k_e = 0.5$ $H = 1.87$ FT (CHART #5) $d_c = 2.70$ FT (CHART #4) $\frac{d_c + D}{2} = 3.1$

$H_o = 3.1$ FT $LS_o = (135)(.004) = .54$ $H_w = H + h_o - LS = \underline{4.43 \text{ FT}}$

FOR INLET CONTROL: (USING HEC 5 MANUAL)

(SQUARE EDGE W/HEADWALL)

$\frac{HW}{D}$ (CHART #1) = 1.35

$HW = D(1.35) = (3.5)(1.35) = \underline{4.725 \text{ FT}}$

∴ INLET CONTROLS, FLOW IS SUPER CRITICAL

FROM FIGURE X1-2, HEC 14:

Y_e = BRINK DEPTH (EQUIV) $= \left(\frac{A}{2}\right)^{1/2}$

$= \left(\frac{(\frac{1}{4}\pi D^2)}{2}\right)^{1/2} = \left(\frac{(\frac{1}{4}\pi (3.5)^2)}{2}\right)^{1/2}$

$= 2.19 \text{ FT}$

FOR DEPTH OF 2.19FT, V= :

$Y_e/D = 2.19/3.5 = .626$

$\frac{A}{D^2}$ = (FROM TABLE III-2, HEC 14) = 0.517

$A = (0.517)(3.5)^2 = 6.337 \text{ FT}^2$

$V = Q/A = 72.5 \text{ cfs}/6.337 = 11.44 \text{ FT/SEC.}$

SELECT A ROCK SIZE

TRY $d_{50} = 9$ IN (FIG II-C-I, HEC 14 w/ $V = 11$ FPS)

$$d_{50}/y_e = .75\,FT / 2.19\,FT = .342$$

$$\text{FROUDE } N_o = V/(g y_e)^{1/2} = 11.44/[(32.2)(2.19)]^{1/2} = 1.36$$

FROM FIG XI-2, HEC 14:

$$\frac{h_s}{y_e} = 0.70$$

$$h_s = (0.70)(2.19) = 1.533\,FT$$

CHECK $\frac{h_s}{d_{50}} = \frac{1.53}{.75} = 2.04$, < 4 AND > 2.0

OK

CHECK $\frac{T_w}{T_o} < 0.75$

$$\frac{T_w = 1.84}{T_o = 3.5} = 0.53$$

NO ADD. RIPRAP REQ'D IN DOWNSTREAM CHANNEL.

BASIN LENGTH ⇒

$10\,h_s = 10(1.53) = 15.3\,FT$

$3\,W_o = 3(3.5) = 10.5\,FT$

$L_B = 5 h_s$

$= 5(1.53) = 7.7\,FT$

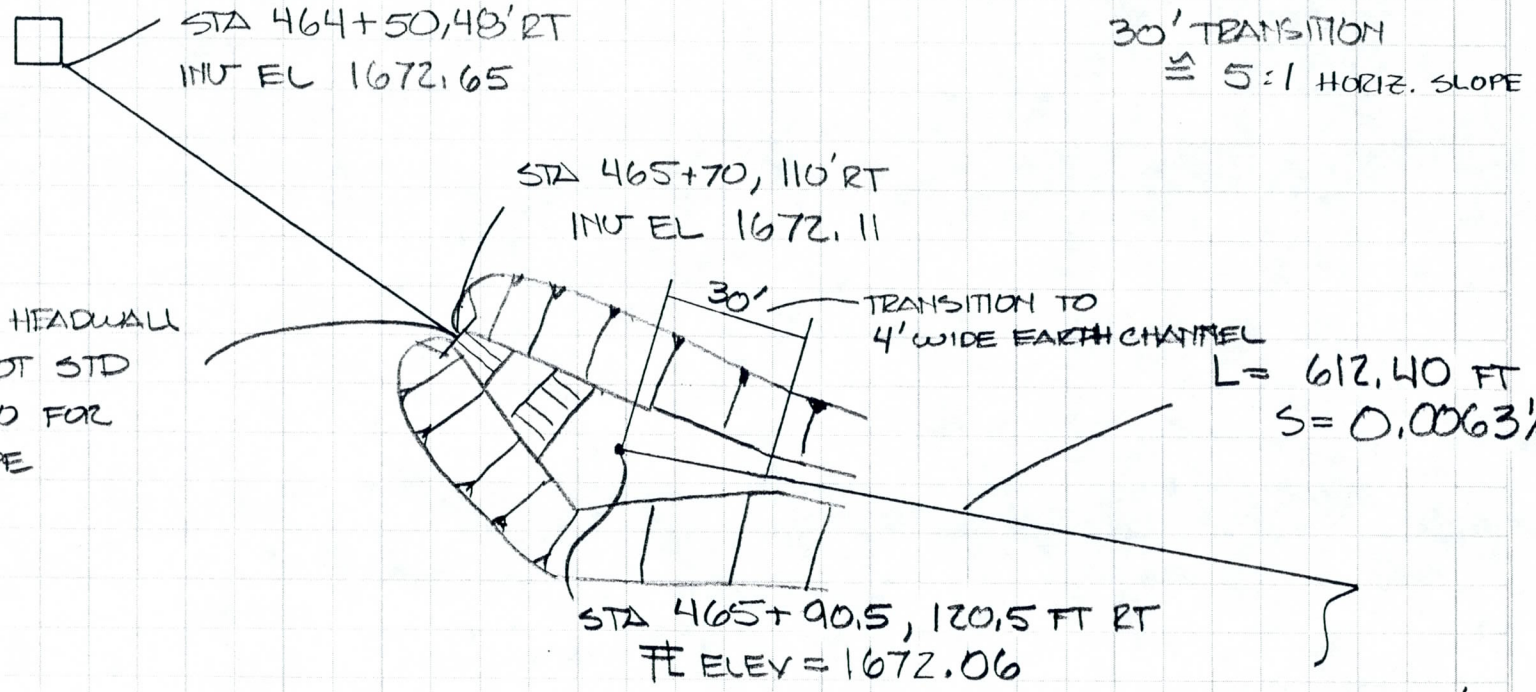
SVERDRUP

JOB TOYOTA 40477

COMPUTATIONS FOR TRACK OUTFALL PIPE

DATE 8/91 BY PMW CHKD RVT

SHEET NO. 4 OF 10



FOR RIP RAP PLUNGE BASIN DETAIL

A	B	C	D	H	L	h_s	T	d_{50}	BOTTOM EL.	(DUMPED)
4.6'	6.1'	7.7'	9.4'	2.9'	15.3'	1.53'	1.5'	.75'	1670.58	"D.R."

SVERDRUP

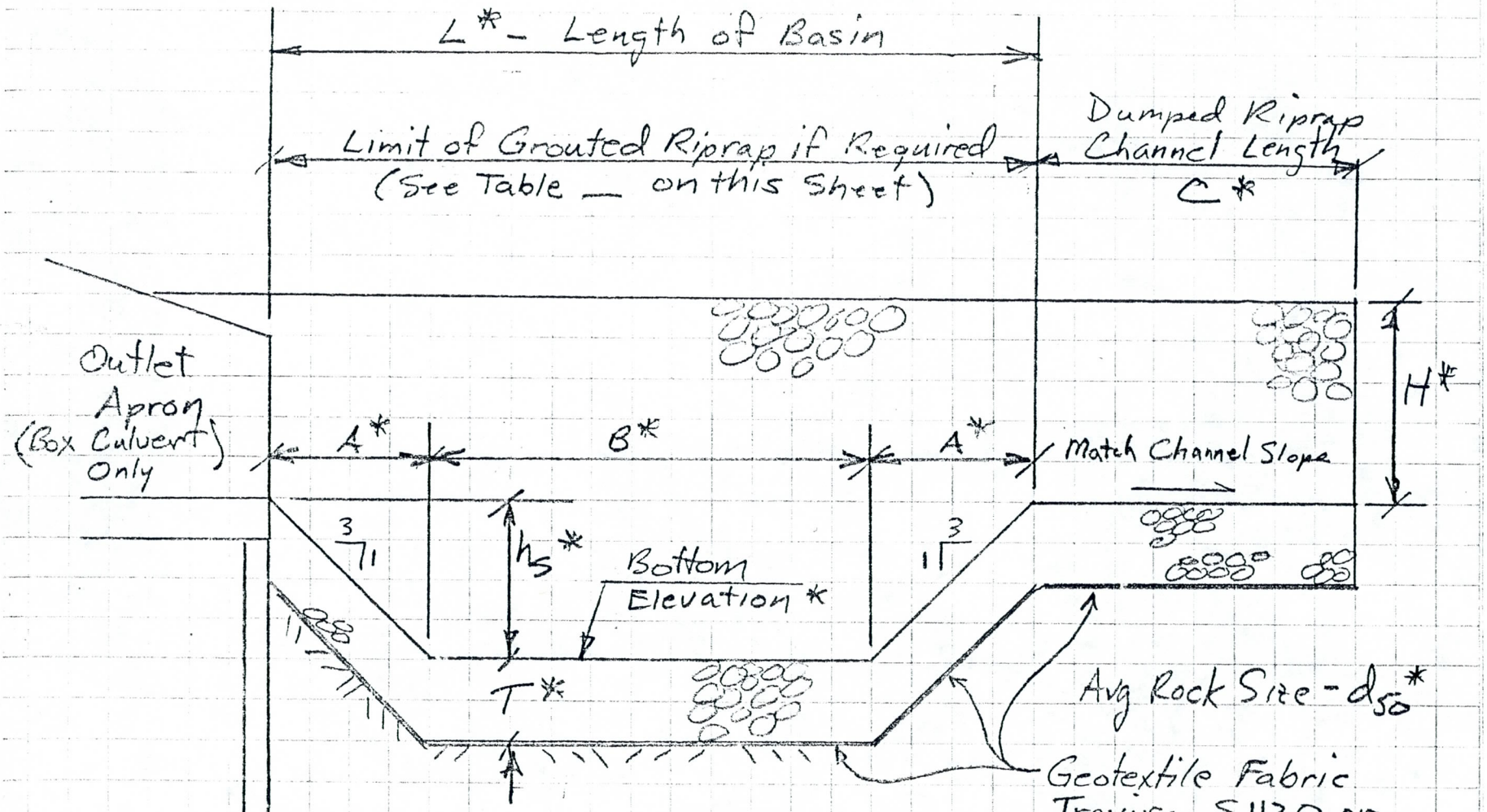
JOB 4077 Toyota

COMPUTATIONS FOR Plunge Basin Detail

SHEET NO. 5 OF 10

DATE 6/29/94

BY BDO CHKD RJT



(A) PLUNGE BASIN & CHANNEL SECTION

N.T.S.

* See Table ___ on This Sheet for Dimensions.

SVERDRUP

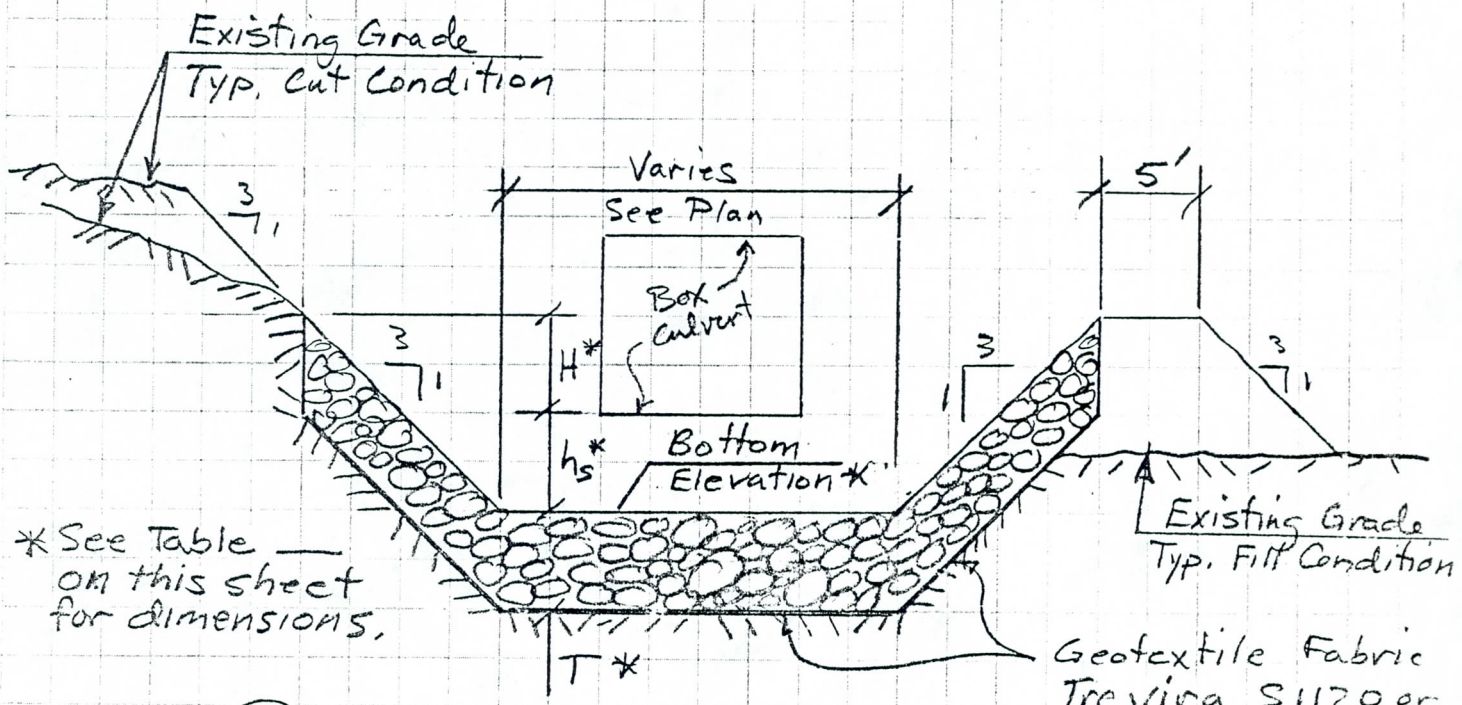
JOB 40477 Toyota

COMPUTATIONS FOR Plunge Basin Detail

SHEET NO. 6 OF 10

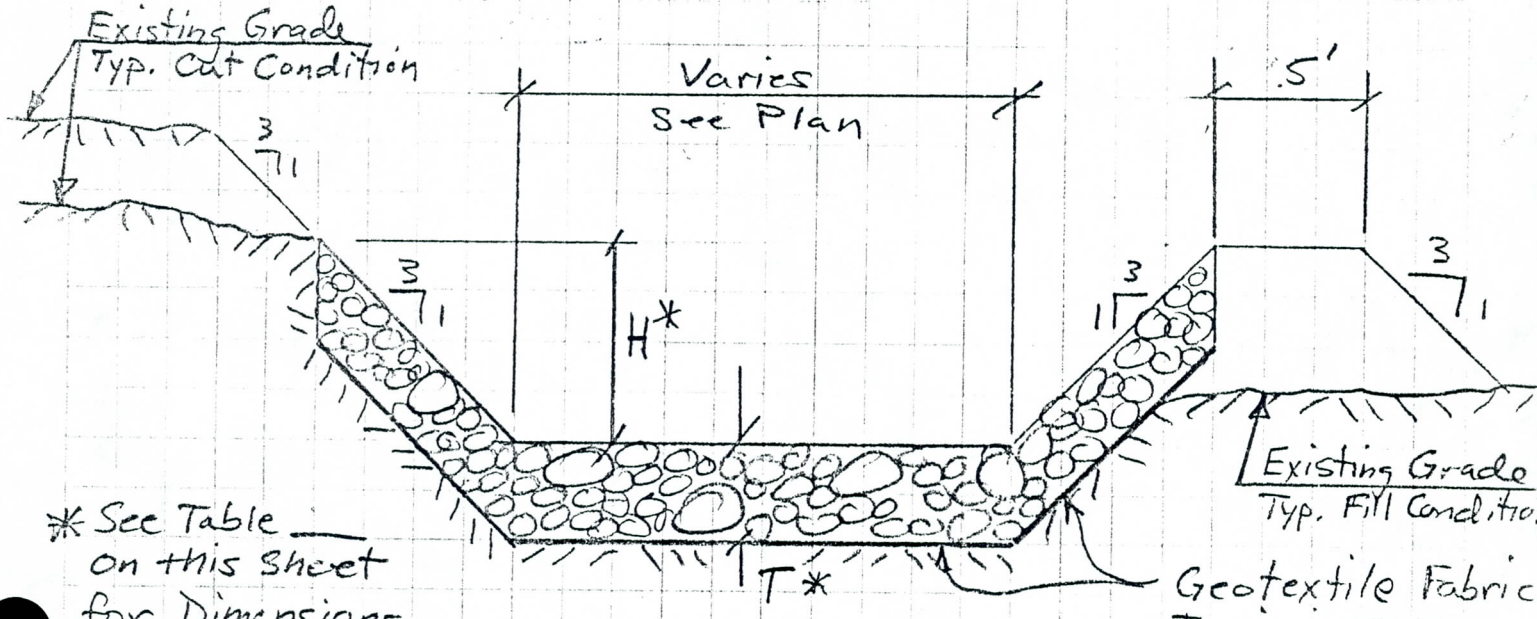
DATE 7/20/91

BY BDO CHKD RJT



*See Table ___ on this sheet for dimensions.

(B) PLUNGE BASIN SECTION
N.T.S.



*See Table ___ on this sheet for Dimensions.

(C) DUMPED RIPRAP CHANNEL SECTION
N.T.S.

SVERDRUP

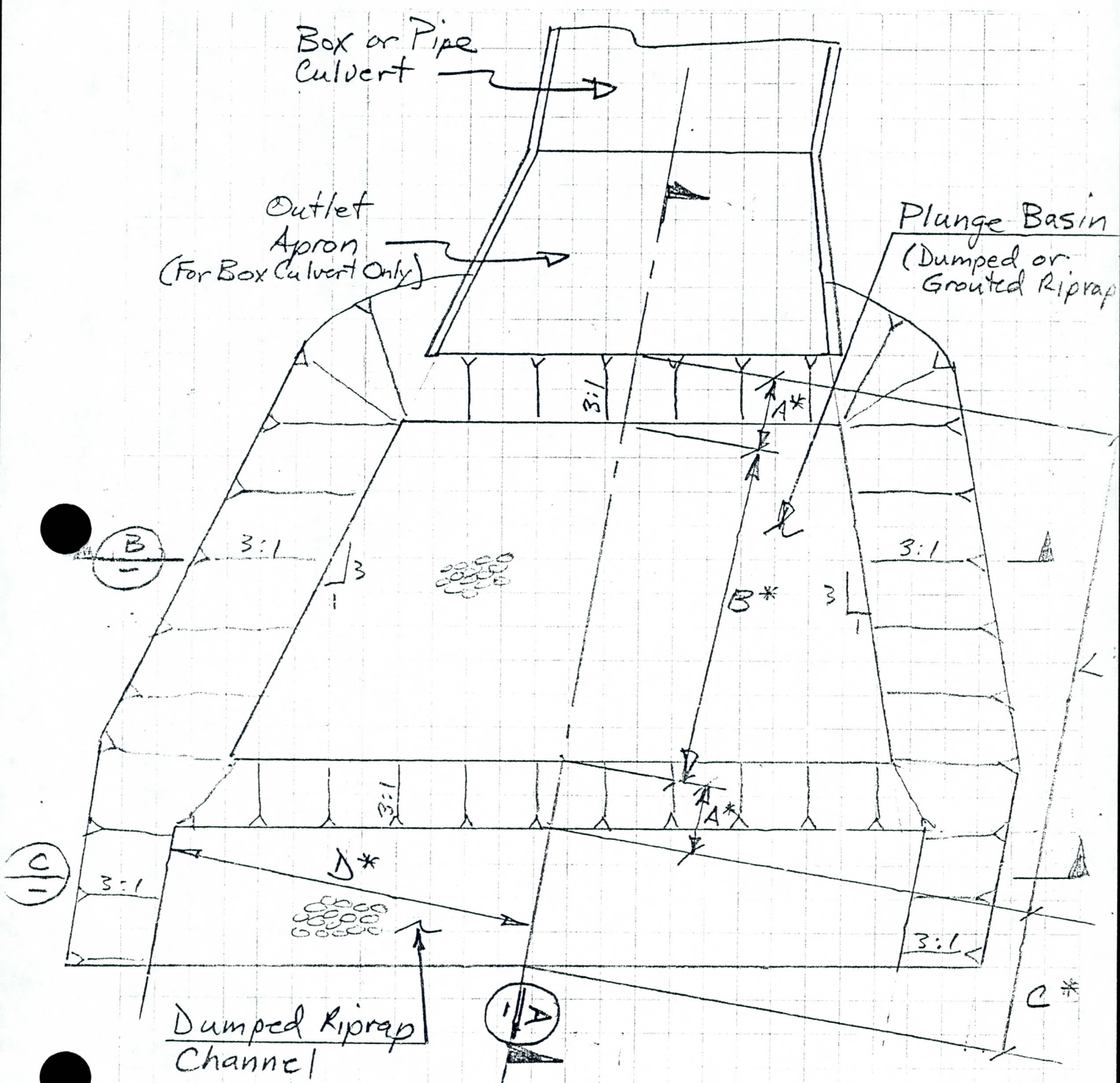
JOB 40477 Toyota

COMPUTATIONS FOR Plunge Basin Detail

SHEET NO. 7 OF 10

DATE 6/29/91

BY BDO CHKD RJT



℄ Channel Plan View

Riprap Plunge Basin

NTS

* See Table ___ on This sheet for Dimensions.

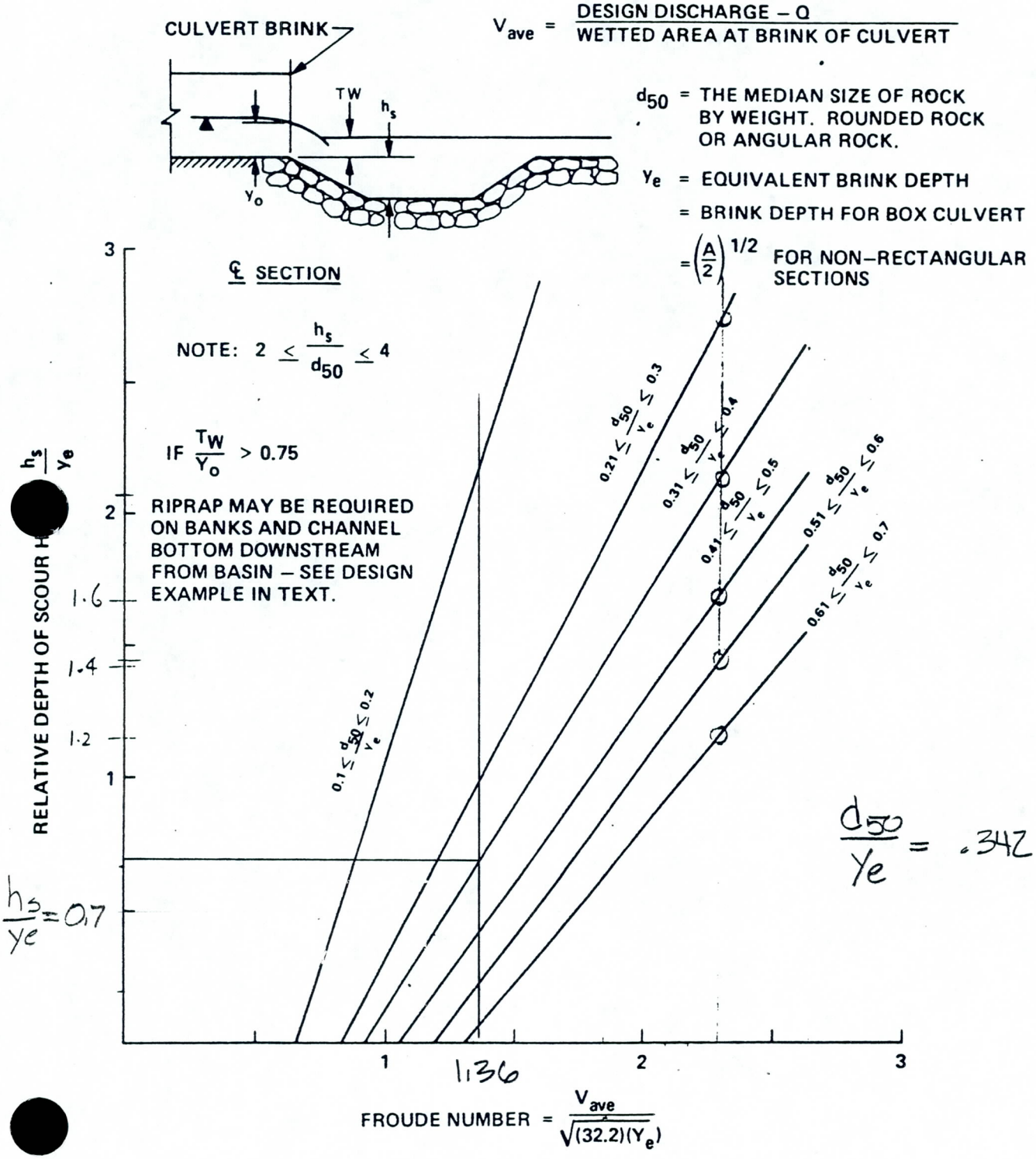


FIGURE X1–2. RELATIVE DEPTH OF SCOUR HOLE VERSUS FROUDE NUMBER AT BRINK OF CULVERT WITH RELATIVE SIZE OF RIPRAP AS A THIRD VARIABLE

9/16

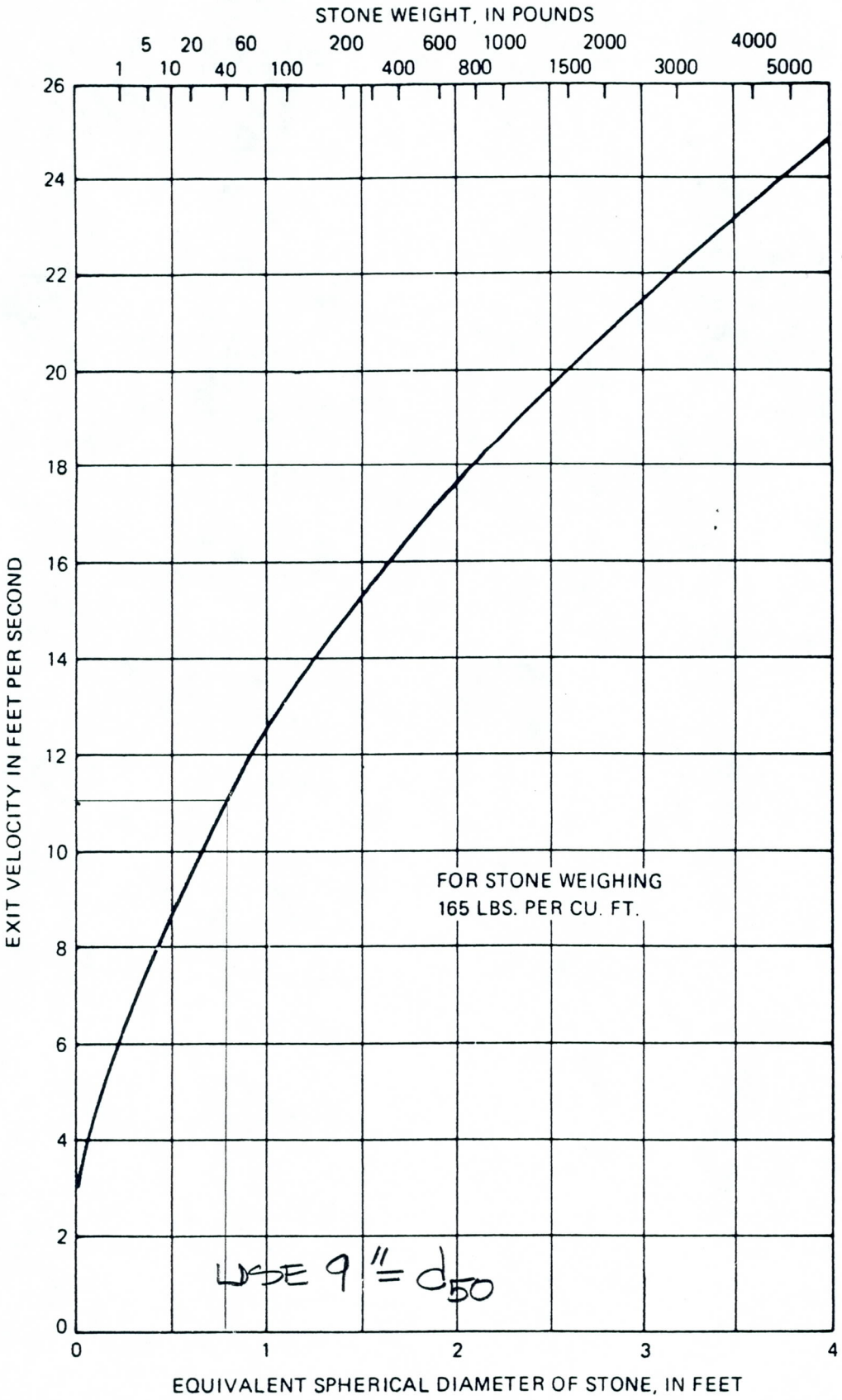
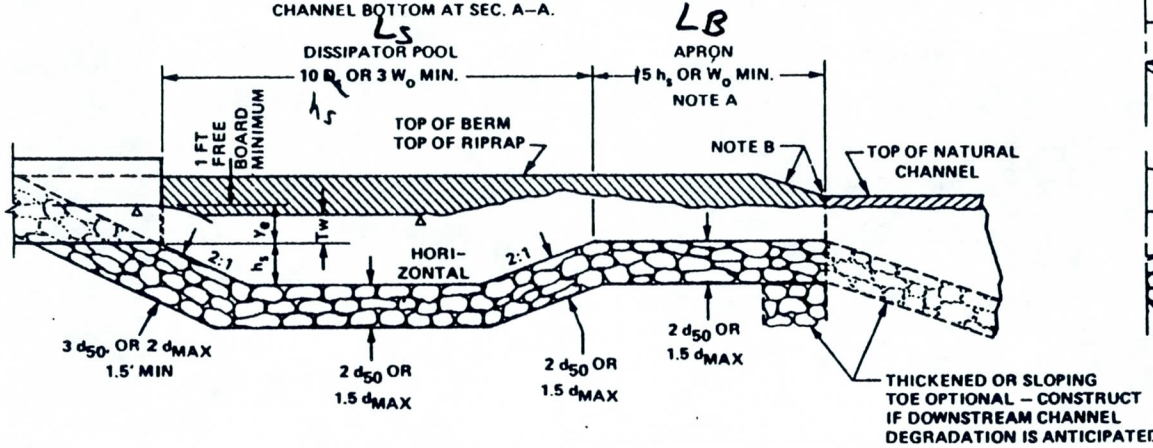


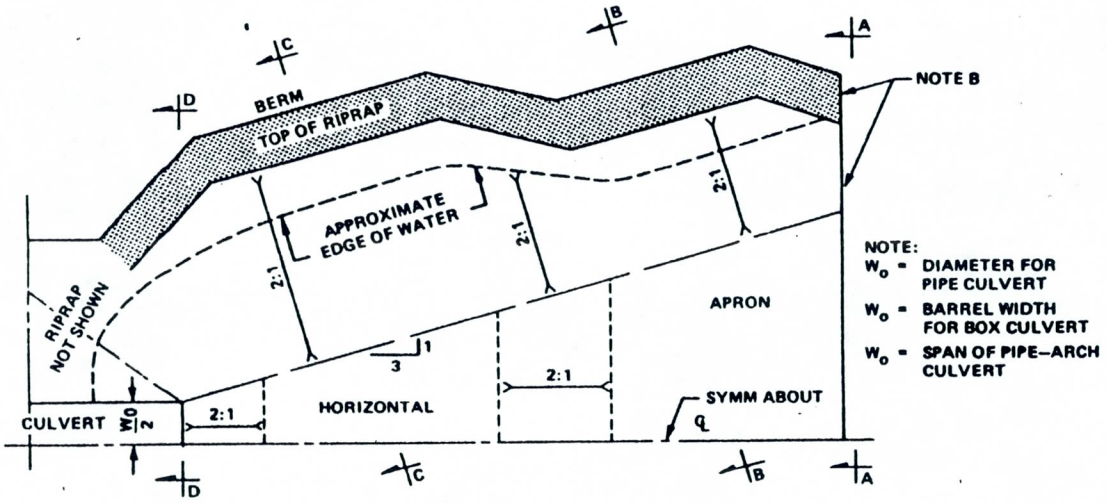
FIGURE II-C-1. RIPRAP SIZE FOR USE DOWNSTREAM OF ENERGY DISSIPATORS FROM REFERENCE II-C-1.

NOTE A – IF EXIT VELOCITY OF BASIN IS SPECIFIED, EXTEND BASIN AS REQUIRED TO OBTAIN SUFFICIENT CROSS–SECTIONAL AREA AT SECTION A–A SUCH THAT Q_{des}/(CROSS SECTION AREA AT SEC. A–A) = SPECIFIED EXIT VELOCITY.

NOTE B – WARP BASIN TO CONFORM TO NATURAL STREAM CHANNEL. TOP OF RIPRAP IN FLOOR OF BASIN SHOULD BE AT THE SAME ELEVATION OR LOWER THAN NATURAL CHANNEL BOTTOM AT SEC. A–A.

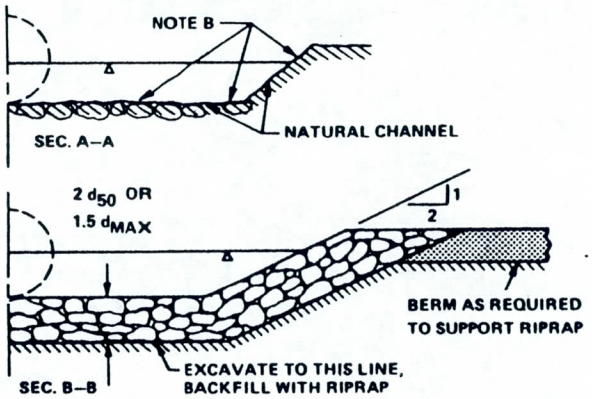


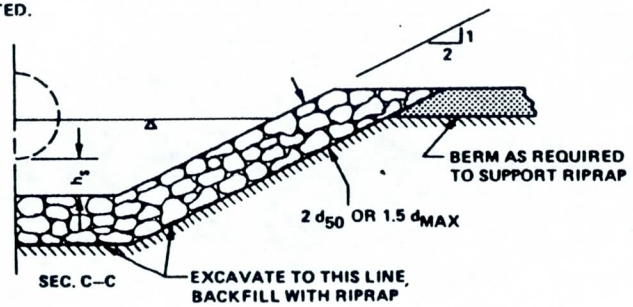
℄ SECTION



HALF PLAN

NOTE:
W_o = DIAMETER FOR PIPE CULVERT
W_o = BARREL WIDTH FOR BOX CULVERT
W_o = SPAN OF PIPE–ARCH CULVERT





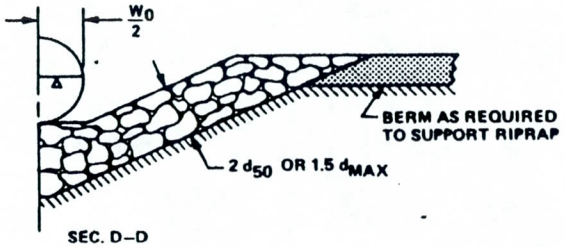
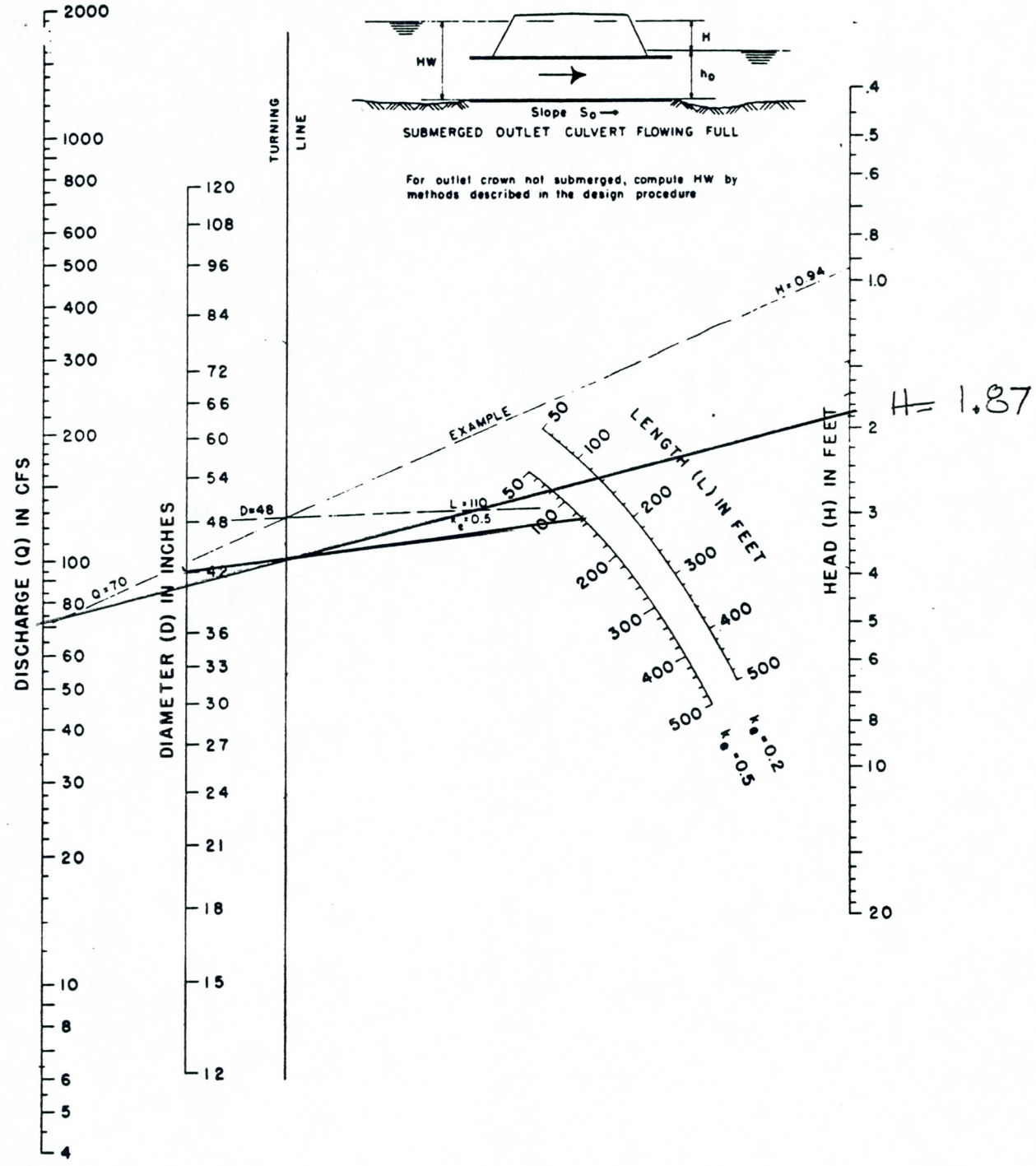


FIGURE X1–1. DETAILS OF RIPRAPPED CULVERT ENERGY BASIN

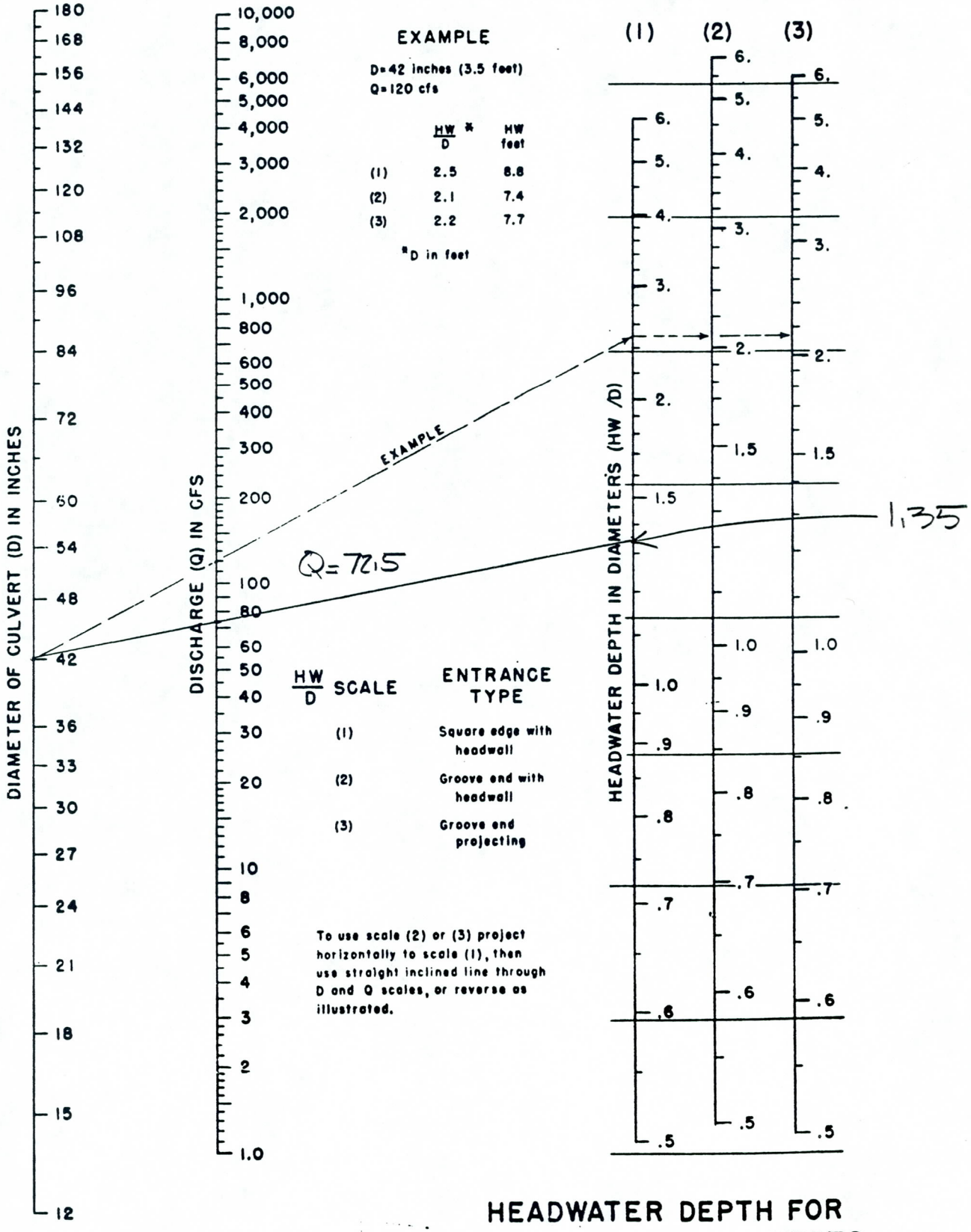
CHART 5



HEAD FOR
CONCRETE PIPE CULVERTS
FLOWING FULL
n = 0.012

BUREAU OF PUBLIC ROADS JAN. 1963

CHART 1



HEADWATER DEPTH FOR CONCRETE PIPE CULVERTS WITH INLET CONTROL

HEADWATER SCALES 283
REVISED MAY 1964

BUREAU OF PUBLIC ROADS JAN. 1963

Toyota - Arizona Proving Ground

8/21/91

Oval Track Retention Volumes

Track Area to be Retained			Pavement Section	Runoff Coeff.	Shoulder Section	Runoff Coeff.	Retention Basin	Runoff Coeff.	Weighted Runoff Coeff.	Rainfall (Inches)	Total Area (Acres)
254+00	to	257+60	360x54	0.95	360x11.8	0.50	75x50	1.00	0.89	3.3	0.668
257+60	to	264+00	640x54	0.95	640x11.5	0.50	125x50	1.00	0.89	3.3	1.157
264+00	to	272+70	870x54	0.95	870x15.8	0.50	150x50	1.00	0.87	3.3	1.625
272+70	to	278+50	580x54	0.95	580x19.8	0.50	125x50	1.00	0.86	3.3	1.178
278+50	to	283+50	500x54	0.95	500x21.3	0.50	100x50	1.00	0.85	3.3	1.024
283+50	to	288+90	540x54	0.95	540x21.3	0.50	100x50	1.00	0.85	3.3	1.093
288+90	to	297+50	860x54	0.95	860x22.8	0.50	150x50	1.00	0.84	3.3	1.747
320+00	to	326+50	650x54	0.95	650x22.3	0.50	125x50	1.00	0.85	3.3	1.334
326+50	to	331+25	475x54	0.95	475x23.3	0.50	100x50	1.00	0.84	3.3	1.002
331+25	to	338+00	675x54	0.95	675x23.3	0.50	125x50	1.00	0.84	3.3	1.393
338+00	to	341+00	300x54	0.95	300x23.3	0.50	75x50	1.00	0.85	3.3	0.656
341+00	to	344+00	300x54	0.95	300x25.3	0.50	75x50	1.00	0.84	3.3	0.670
344+00	to	347+50	350x54	0.95	350x22.3	0.50	75x50	1.00	0.85	3.3	0.737
347+50	to	351+30	380x54	0.95	380x22.3	0.50	75x50	1.00	0.85	3.3	0.789
351+30	to	357+20	590x54	0.95	590x22.8	0.50	100x50	1.00	0.84	3.3	1.164
357+20	to	361+40	420x54	0.95	420x20.5	0.50	75x50	1.00	0.86	3.3	0.878
361+40	to	365+00	360x54	0.95	360x18.3	0.50	75x50	1.00	0.86	3.3	0.721

Toyota - Arizona Proving Ground 8/21/91

Oval Track Retention Volumes

Track Area to be Retained			Calculated Runoff Volume (Acre Ft)	Calculated Runoff Volume (Cu Ft)	Pav't Length (Ft)	Pav't Width (Ft)	Pav't Area (SF)	Shoulder Length (Ft)	Shoulder Width (Ft)	Shoulder Area (SF)	Retention Area (SF)
254+00	to	257+60	0.164	7,146	360	54	19,440	360	11.8	4,248	5394
257+60	to	264+00	0.284	12,377	640	54	34,560	640	11.5	7,360	8494
264+00	to	272+70	0.389	16,926	870	54	46,980	870	15.8	13,746	10044
272+70	to	278+50	0.278	12,097	580	54	31,320	580	19.8	11,484	8494
278+50	to	283+50	0.239	10,428	500	54	27,000	500	21.3	10,650	6944
283+50	to	288+90	0.255	11,109	540	54	29,160	540	21.3	11,502	6944
288+90	to	297+50	0.404	17,591	860	54	46,440	860	22.8	19,608	10044
320+00	to	326+50	0.310	13,499	650	54	35,100	650	22.3	14,495	8494
326+50	to	331+25	0.233	10,132	475	54	25,650	475	23.3	11,068	6944
331+25	to	338+00	0.322	14,021	675	54	36,450	675	23.3	15,728	8494
338+00	to	341+00	0.153	6,677	300	54	16,200	300	23.3	6,990	5394
341+00	to	344+00	0.155	6,759	300	54	16,200	300	25.3	7,590	5394
344+00	to	347+50	0.172	7,494	350	54	18,900	350	22.3	7,805	5394
347+50	to	351+30	0.184	8,009	380	54	20,520	380	22.3	8,474	5394
351+30	to	357+20	0.268	11,656	590	54	31,860	590	22.8	13,452	5394
357+20	to	361+40	0.207	9,019	420	54	22,680	420	20.5	8,610	6944
361+40	to	365+00	0.171	7,468	360	54	19,440	360	18.3	6,588	5394

8/21/91

Cumulative Volume Computations for Retention Basins On North Tangent Section of Oval Track

Retention Basin (75'x 50')

Elev.	Area (Acres)	Storage Volume (Acre Ft)	Cumulative Volume (Acre Ft)	Cumulative Volume (Cu Ft)
0	0.09	0.00	0.00	0
2	0.12	0.21	0.21	9,094

Retention Basin (100'x 50')

Elev.	Area (Acres)	Storage Volume (Acre Ft)	Cumulative Volume (Acre Ft)	Cumulative Volume (Cu Ft)
0	0.11	0.00	0.00	0
2	0.16	0.27	0.27	11,891

Retention Basin (125'x 50')

Elev.	Area (Acres)	Storage Volume (Acre Ft)	Cumulative Volume (Acre Ft)	Cumulative Volume (Cu Ft)
0	0.14	0.00	0.00	0
2	0.20	0.34	0.34	14,688

Retention Basin (150'x 50')

Elev.	Area (Acres)	Storage Volume (Acre Ft)	Cumulative Volume (Acre Ft)	Cumulative Volume (Cu Ft)
0	0.17	0.00	0.00	0
2	0.23	0.40	0.40	17,484

SVERDRUP

JOB 40477 Toyota

SHEET NO. 1 OF 1

DATE 8/21/91

COMPUTATIONS FOR Retention Basins
North Tangent Section

BY BDO CHKD D.F.P.

Maximum depth of Runoff in Retention Basins is 2 feet.

From percolation tests conducted at three locations along the north tangent segment, the range was from 2.1 to 4.3 minutes/inch.

Using a conservative value of 10 minutes/inch would result in an hourly rate of 6 inches/hr.

$$\frac{1 \text{ inch}}{10 \text{ minutes}} \times \frac{60 \text{ minutes}}{\text{hour}} = 6 \text{ inches/hr.}$$

For a maximum depth of runoff in a retention basin the time required for percolation is:

$$2 \text{ ft} \times \frac{12 \text{ inches}}{1 \text{ ft}} \times \frac{\text{hour}}{6 \text{ inches}} = 4 \text{ hours}$$

OK