Flood Control District
of Maricopa County, Arizona
Indian Bend Wash Inlet
Valley Vista Drainage Structures
Design

A680.609

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of
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INDIAN BEND WASH
INLET CHANNEL

DESIGN
VALLEY VISTA DRAINAGE STRUCTURES

Prepared by
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April 21, 1978

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Valley Vista Side Drains
Hydraulic Design

Side drains discharge into an outlet basin tied into the golf course lake north of McDonald Drive and east of Hayden Rd. as shown on plan sheet 24. Pipe profiles are shown on plan sheet 25. Discharge is controlled by allowable head on each inlet and outlet tailwater resulting from contemporaneous Inlet Channel flows into the golf course lake (given in Table 3-3 Inlet FDM for C.P. 303.) The total Inlet Channel flow at 100 yr. peak local inflow for C.P. 303 is 8600 cfs. McDonald Bridge is designed to carry 8000 cfs. under McDonald with zero spill crossing Hayden Rd. into the golf course. At 8600 cfs, slightly less than 600 cfs will spill across Hayden Rd. Use 600 cfs for purposes of this design. From the "Lateral Drainage of Indian Bend Wash Project" prepared by Sullivan & Masson, Consulting Engineers, the 100 year local discharge at C.P. 303 is (Exhibit 7: (25+160+160) 345 cfs. Tailwater on the outlet results from weir flow across McDonald of (600+345) 945 cfs. Using the following profile of McDonald Dr. Scaled from

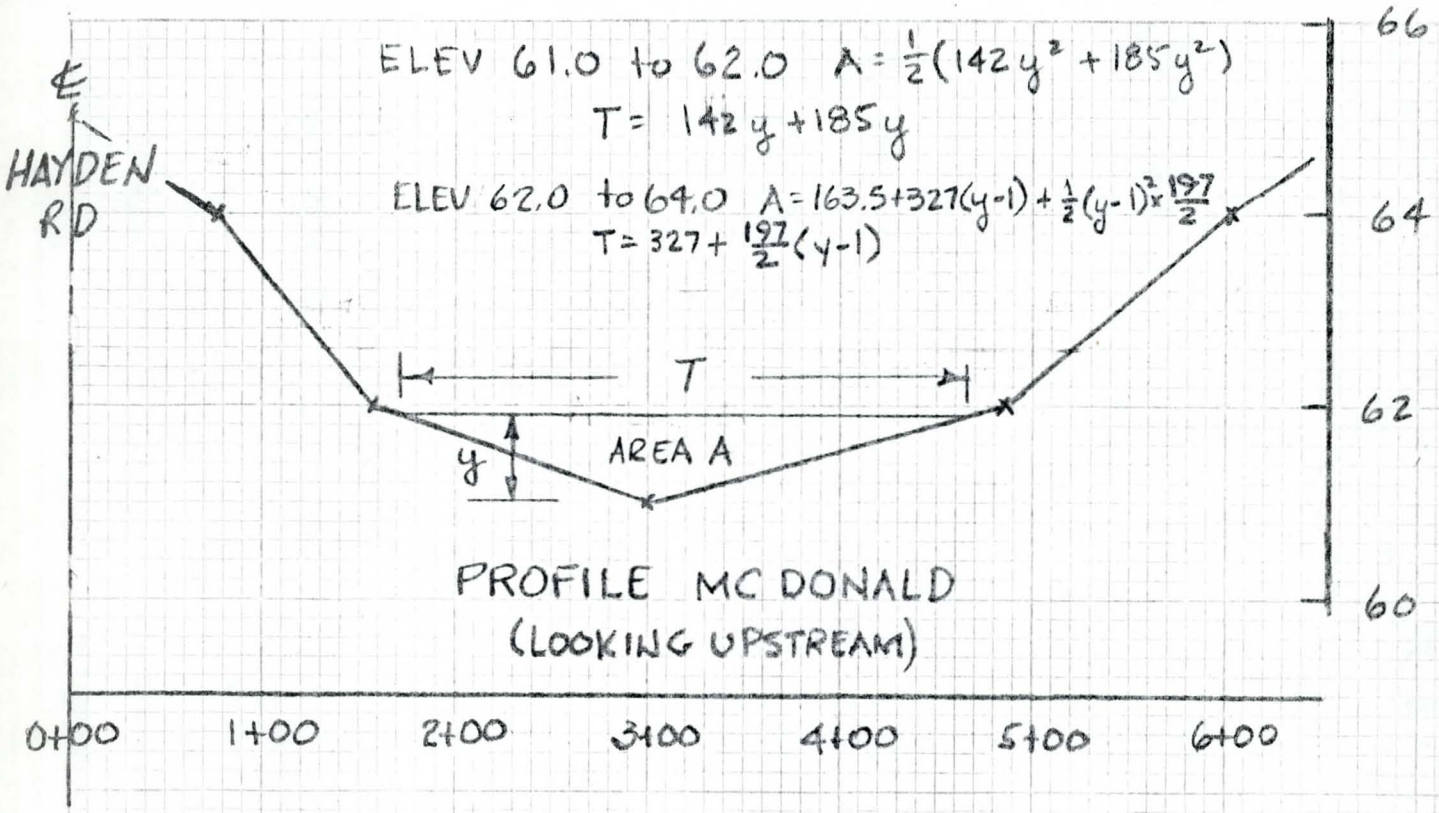

ELEV 61.0 to 62.0 $A = \frac{1}{2}(142y^2 + 185y^2)$
$T = 142y + 185y$
ELEV 62.0 to 64.0 $A = 163.5 + 327(y-1) + \frac{1}{2}(y-1)^2 \times \frac{197}{2}$
$T = 327 + \frac{197}{2}(y-1)$
℄
HAYDEN RD
T
y
AREA A
66
64
62
60
0+00
1+00
2+00
3+00
4+00
5+00
6+00
PROFILE MC DONALD
(LOOKING UPSTREAM)

Fig. 1

Corps topography and assuming critical depth occurs within the limits of McDonald Drive, tailwater on the outlet structure analysis is as follows:

Assume $y_c = 1.15'$ (Z = ELEV 1262.15)

$A = 213.7\ ft^2$ $\quad T = 341.8\ ft$

for critical flow $\frac{D_c}{2} = \frac{V_c^2}{2g}$ $\quad (D = \frac{A}{T})$

$Q^2 = \frac{g A^3}{T}$ $\quad Q = 958.6$ cfs (OK > 945 design)

$V = \frac{Q}{A} = 4.49$ ft/sec. $\quad V^2/2g = 0.31$

Total energy required $= Z + V^2/2g = 1262.15 + 0.31 = 1262.46$

Assume lake velocity zero, use lake elev. 1263.00

Approximate loss over sill at entry of outlet basin into lake - Sill Elev. = 1258.5

at depth of flow [1263.0 - 1258.5] = 4.5' average width of flow is 25.5'. Use loss coefficient for streamlined expansion & contraction $C_{e+c} = 0.3$

$V = \frac{435\ cfs}{4.5' \times 25.5'} = 3.79$ ft/sec $\quad V^2/2g = 0.22'$

$h_{e+c} = 0.07'$

H = Energy grade in basin = 1263.0 + 0.07 = 1263.07

Depth of flow in basin appx. 6' - average width = 29'

$V = 2.50$ ft/sec $\quad V^2/2g = 0.10'$

Z = Hydraulic Grade in basin = 1263.07 - 0.10 = 1262.97

Hydraulic Gradient in basin negligible (V=2.5 ft/sec - Length 20')

Use as conditions on outlet of pipes "A", "B" & "C"

H = 1263.10 Z = 1263.00

Use Manning Eq. - full pipe flow for calculation.

Pipe "A"

Q = 160 cfs Pipe Dia. = 54" n = 0.013 (BuRec for conc. pipe ≧24" Dia.) $V = \frac{160 cfs}{15.90 ft^2} = 10.06 ft/sec$ $V^2/2g = 1.57'$

$$S_f = \left(\frac{Q\,n}{1.486\,A\,R^{2/3}}\right)^2 = \left[\frac{160 \times 0.013}{1.486 \times 15.90 \times (1.125)^{2/3}}\right]^2 = 0.00662$$

① to ② Pipe exit loss use $h_L = C_{exit} \frac{V^2}{2g}$ $C_{exit} = 1.0$

② to ③ Pipe friction loss $h_f = Length \times S_f$

③ to ④ Loss through gate structure use

$$h_L = h_{entr.} + h_{exit} + h_{gate} = [\Sigma C]\frac{V^2}{2g}$$

gate loss - use Corps design criteria on flap gate coefficients $K = f\left(\frac{Pipe\ Dia}{V^2/2g}\right) = f(2.87)$

from chart $k = 0.05$

entrance & exit loss - assume that 50% of velocity head preserved as submerged jet through structure

$$C_{str} = 0.5(C_{entr.} + C_{exit}) = 0.5(0.5+1.0)$$

$C_{str} = 0.75$ $\Sigma C = 0.80$

④ to ⑤ Pipe friction loss $h_f = \text{length} \times S_f$

⑤ to ⑥ Bend loss + contraction loss, structure transition to pipe (4.5×8' box @ entrance to 54" pipe)

Bend loss use 90° for large diameter pipes from King & Brater (P.6-23) $\frac{\text{Dia Bend}}{\text{Dia Pipe}} = 1.0$

$C_{90°} = 0.23$ Velocity at bend

$V = \frac{160 \text{ cfs}}{4.5' \text{ high} \times 7.0' \text{ wide}} = 5.08 \text{ ft/sec}$ $\frac{V^2}{2g} = 0.40$

Contraction loss from King & Brater (Table 6-10)

$h_L = K_3 \frac{V_2^2}{2g}$ V_2 of smaller pipe = 10 ft/sec

and $K_3 = f(\frac{d_2}{d_1}, V_2)$ approximate $\frac{d_2}{d_1}$ by

$\left(\frac{A_{box}}{A_{pipe}}\right)^{1/2} = \left(\frac{36.0}{15.90}\right)^{1/2} = 1.5$ $K_3 = 0.22$

$V_{entrance} = \frac{160}{4.5 \times 8} = 4.07$ $\frac{V^2}{2g} = 0.26$

⑥ to ⑦ Entrance to Str. use $C_{entr} = 0.5$

⑦ to ⑧ Open Channel Contraction Sill to box entrance

Contraction loss from King & Brater (p. 8-31)

$h_c = K_c \left(\frac{V_2^2}{2g} - \frac{V_1^2}{2g}\right)$

for sudden change, sharp corners $K_c = 0.5$ for "well designed" $K_c = 0.1$. Change in cross section is somewhat gradual

except that sharp corners along edge of sloping headwall and the trashrack increase losses. Use $K_c = 0.3$

Flow area at sill is 19.5' wide along sill and 33.5' top width at WSE 1268.5, assumed.

$y = 2.5'$

$$V_{sill} = \frac{160}{.5(33.5+19.5)2.5} = 2.42 \text{ ft/sec}$$

$$V^2/2g = 0.09$$

Calculation of hydraulic profiles follows on Sheet 6

42-381 50 SHEETS 5 SQUARE
42-382 100 SHEETS 5 SQUARE
42-389 200 SHEETS 5 SQUARE
NATIONAL

Side Drain Valley Vista Pipe "A" HYDRAULIC CALCULATIONS

Indian Bend Wash Inlet

By BJ 4-14-78 Ck

Point	LINE "A" Station	Reach Description	Energy Grade Line Elevation	Hydraulic Grade Line Elevation	Head Loss Calculation
1	9+99 Bk		1263.10	1263.00	
		Pipe Exit			$h_{ex} = 1.0 \times 1.57' = 1.57'$
2	9+99 Ahd		1264.67	1263.10	
		97.9 L.F. 54" RGRCP			$h_f = 97.9' \times 0.00662 = 0.65'$
3	10+96.9		1265.32	1263.75	
		Flap Gate Str.			$h_{str} = 0.80 \times 1.57' = 1.26'$
4	11+04.4		1266.58	1265.01	
		149.2 L.F. 54" RGRCP			$h_f = 149.2' \times 0.00662 = 0.99'$
5	12+53.57	Inlet Structure Transition Box	1267.57	1266.00	$h_{bend} = 0.23 \times 0.40' = 0.09'$ $h_{contr} = 0.22 \times 1.57' = 0.35'$ $\Sigma = 0.44'$
6	12+61.74 Bk	Transition Box Entrance	1268.01	1267.75	$h_{ent} = 0.5 \times 0.26' = 0.13'$
7	12+61.74 Ahd	Open Channel Contraction, Apron sill to Entr.	1268.14	1267.88	$h_{contr} = 0.3(0.26' - 0.09') = 0.05'$
8	12+72.74		1268.19	1268.10	
					WSE @ (8) = 1268.10
					- MAX ALLOWABLE
					1268.50 - DESIGN IS
					WITHIN ALLOWABLE
					LIMITS

Pipe "B"

$Q = 160$ cfs Pipe Dia $= 60"$ $n = 0.013$ (BuRec for conc. pipe $\geq 24"$ Dia.) $V = \frac{160 \text{ cfs}}{19.63 \text{ ft}^2} = 8.15$ ft/sec

$V^2/2g = 1.03'$ $S_f = \left(\frac{Qn}{1.486 A R^{2/3}}\right)^2 = \left(\frac{160 \times 0.013}{1.486 \times 19.63 \times (1.25)^{2/3}}\right)^2 = 0.00378$

(9) to (10) Pipe exit loss use $C_{exit} = 1.0$

(10) to (11) Pipe friction loss $h_f = \text{Length} \times S_f$

(11) to (12) Loss through gate structure use

$h_L = h_{entr.} + h_{exit} + h_{gate} = [\Sigma C] V^2/2g$

gate loss - Corps design criteria for

$\frac{\text{Pipe Dia}}{V^2/2g} = \frac{5}{1.03} = 4.85$ $k = 0.15$

entrance & exit loss coefficients per Pipe "A" sheet 3 $C_{str} = 0.75$

$\Sigma C = 0.90$

(12) to (13), (14) to (15), (16) to (17) } Pipe friction loss $h_f = \text{Length} \times S_f$

(13) to (14), (15) to (16), (17) to (18) } Bend loss - Bend at 11+51.85 is 26° + at 14+58.04 and 14+80.25 Bends are 22.5° Use loss for 22.5° bend all 3 locations for $\frac{R}{d} = 1$ large pipes 90° bend $k_b = 0.23$

for 22.5° bend $K_b = 0.5 K_{90°}$ $K_b = 0.12$
(King & Brater p. 6-23)

(19) to (20) Contraction loss from box into pipe
At junction between pipe and box effective flow area of box is 8' wide x assumed 5' (pipe dia) because of flow entering box vertically. Approximate
$\frac{\text{Dia. Box}}{\text{Dia Pipe}}$ by $\left(\frac{A_{box}}{A_{pipe}}\right)^{1/2} = \left(\frac{40}{19.63}\right)^{1/2} = 1.4$

(Table 6-10 King & Brater) $h_L = k_3 V_2^2/2g$
$V_2 = V_{pipe} = 8.15 ft/sec$ $k_3 = 0.17$

(20) to (21) Entrance loss - slightly streamlined transition into box (Ground slopes into box from 2:1 to 3:1) $C_{entr} = 0.3$
$V_{box\ inlet} = \frac{146 cfs}{8' \times 16'} = 1.14$ (Surface flow into box = 146 cfs) $V^2/2g = 0.02'$

Transition from entrance to horizontal flow in box at pipe entrance use sudden contraction King & Brater Table 6-10 for
$\frac{d_2}{d_1} = \left(\frac{A_2}{A_1}\right)^{1/2} = \left(\frac{16' \times 8'}{5' \times 8'}\right) = 3.2$ $V_{smaller} = \frac{160 cfs}{5 \times 8'} = 4.00 ft/sec$
$V_2^2/2g = 0.25'$ $K_3 = 0.44$

Loss through horizontal trashrack - assume

50% plugged - Use Sudden contraction and sudden expansion King & Brater Tables 6-10 and 6-7 for $\frac{dia_2}{dia_1} = \left(\frac{A_2}{A_1}\right)^{1/2} = 2^{1/2} = 1.4$

$V_{smaller} = \frac{146 cfs}{.5 \times 8 \times 16'} = 2.28$ ft/sec $\quad V^2/2g = 0.08'$

K_3 (contr) $= 0.17$ $\quad K_2$ (exp.) $= 0.26$

$\Sigma K = 0.43$

Calculation of hydraulic profiles follows on sheet 10

42-381 50 SHEETS 5 SQUARE
42-382 100 SHEETS 5 SQUARE
42-389 200 SHEETS 5 SQUARE
NATIONAL

Side Drain Valley Vista Pipe "B" HYDRAULIC CALCULATIONS

Indian Bend Wash Inlet

By BG. 4-14-78
Ck

Point	Line "B" Station	Reach Description	Energy Grade Line Elevation	Hydraulic Grade Line Elevation	Head Loss Calculation
9	9+99 Bk		1263.10	1263.00	
		Pipe Exit			$h_{exit} = 1.0 \times 1.03' = 1.03'$
10	9+99 Ahd		1264.13	1263.10	
		97.9 L.F. 60" RGRCP			$h_f = 97.9' \times 0.00378 = 0.37'$
11	10+96.9		1264.50	1263.47	
		Flap Gate Str.			$h_{str.} = 0.90 \times 1.03' = 0.93'$
12	11+04.4		1265.43	1264.40	
		47.5 L.F. 60" RGRCP			$h_f = 47.5' \times 0.00378 = 0.18'$
13	11+51.85 Bk		1265.61	1264.58	
		26° Bend			$h_b = 0.12 \times 1.03' = 0.12'$
14	11+51.85 Ahd		1265.73	1264.70	
		326.2 L.F. 60" RGRCP			$h_f = 326.2' \times 0.00378 = 1.23'$
15	14+78.04 Bk		1266.96	1265.93	
		22.5° Bend			$h_b = 0.12 \times 1.03' = 0.12'$
16	14+78.04 Ahd		1267.08	1266.05	
		22.2 L.F. 60" RGRCP			$h_f = 22.2' \times 0.00378 = 0.08'$
17	15+00.25 Bk		1267.16	1266.13	
		22.5° Bend			$h_b = 0.12 \times 1.03' = 0.12'$
18	15+00.25 Ahd		1267.28	1266.25	
		7.8 L.F. 60" RGRCP			$h_f = 7.8' \times 0.00378' = 0.03'$
19	15+08 Bk		1267.31	1266.28	
		Transition from box to pipe			$h_{contr} = 0.17 \times 1.03' = 0.18'$
20	15+08 Ahd		1267.49	1267.24	
		Entrance from surface thru grate to horiz. flow			$h_{contr} = 0.44 \times 0.25' = 0.11'$ $h_{grate} = 0.43 \times 0.08' = 0.03'$ $h_{entr} = 0.3 \times 0.02' = 0.01'$ $\Sigma h_L = 0.15'$
21	15+16		1267.64	1267.64 Ponded V≈0	

Pipe "C"

$Q = 25$ cfs Pipe Dia = 24" $n = 0.013$ (Bu Rec for conc. pipe ≧ 24" Dia.) $V = \frac{25 cfs}{3.142 ft^2} = 7.96 ft/sec$ $\frac{V^2}{2g} = 0.98'$

$$S_f = \left[\frac{25 \times 0.013}{1.486 \times 3.14 \times (0.5)^{2/3}}\right]^2 = 0.01221$$

(22) to (23) Pipe Exit Loss use $C_{exit} = 1.0$

(23) to (24) Pipe friction loss $h_f = Length \times S_f$

(24) to (25) Loss through gate structure use

$h_L = h_{entr} + h_{exit} + h_{gate}$

gate loss - Corps design criteria for

$\frac{Pipe\ Dia}{V^2/2g} = \frac{2'}{0.98'} = 2.04$ $k = 0.015$

entrance & exit loss coefficients per Pipe "A" sheet 3 $C_{str} = 0.75$

$\Sigma c = 0.77$

(25) to (26) Pipe friction loss $h_f = Length \times S_f$

(26) to (27) Bend + Contraction loss str. transition to pipe

Bend loss use $C_{90°} = 0.23$ velocity at bend: $V = \frac{25 cfs}{2.0'(high) \times 3.1'(wide)} = 4.03$ $\frac{V^2}{2g} = 0.25'$

$V_{entrance} = \frac{25}{2' \times 4'} = 3.13 ft/sec$ $\frac{V^2}{2g} = 0.15'$

Contraction loss King & Brater (Table 6-10) $h_L = K_3 \frac{V_2^2}{2g}$ $V_2 = V(\text{Smaller}) = V_{24"} = 7.96$ ft/sec

$V_2^2/2g = 0.98'$ approximate $\frac{d_2}{d_1}$ by $\left(\frac{A_{box}}{A_{pipe}}\right)^{1/2} = \left(\frac{2' \times 4'}{3.14}\right)^{1/2} = 2.55$ $K_3 = 0.40$

(27) to (28) Entrance to str. use $C_{entr} = 0.5$

(28) to (29) Open channel Contraction sill to box entrance (see sheet 5)

$K_c = 0.3$ $h_c = K_c \left(\frac{V_2^2}{2g} - \frac{V_1^2}{2g}\right)$

Assumed ponding El 1268.5 sill El 1265.0

Width sill (effective) = 18'

$V_{sill} = \frac{25}{3.5' \times 18'} = 0.40$ $\frac{V^2}{2g} = 0$

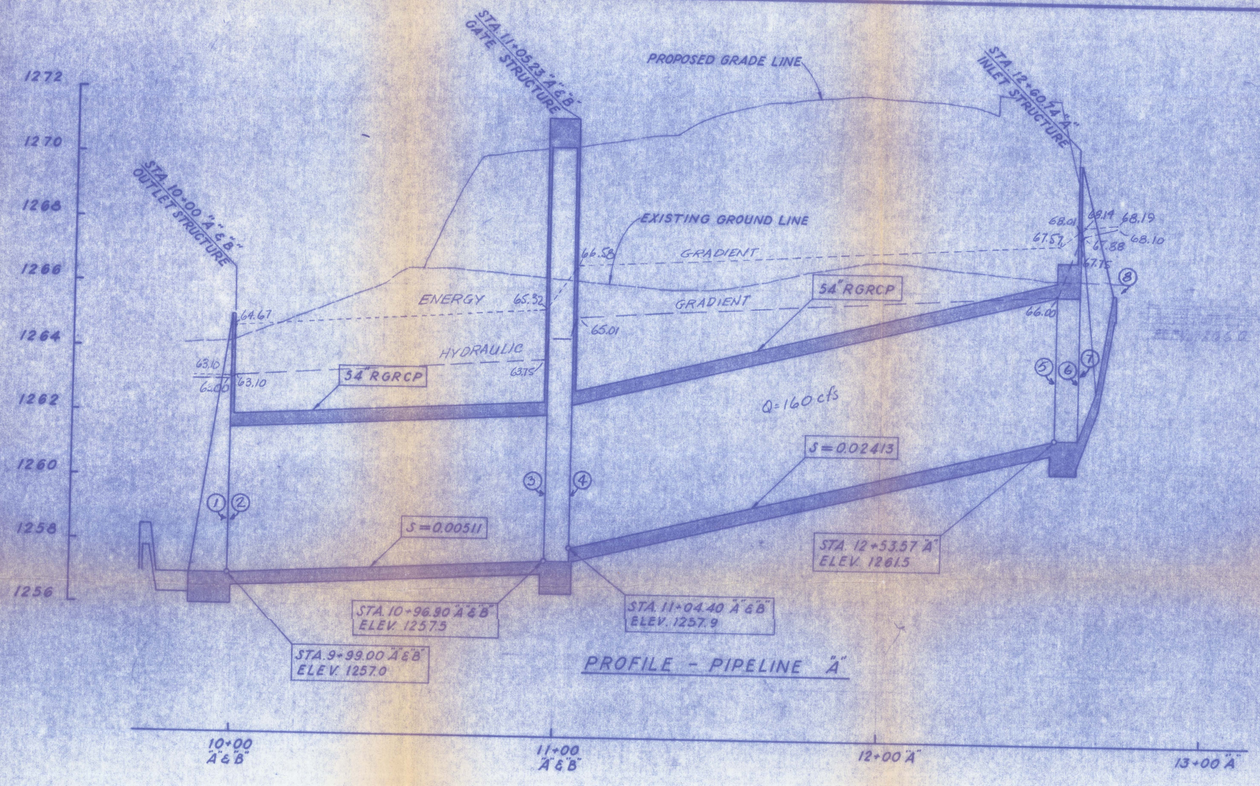
Side Drain Valley Vista Pipe "C" HYDRAULIC CALCULATIONS

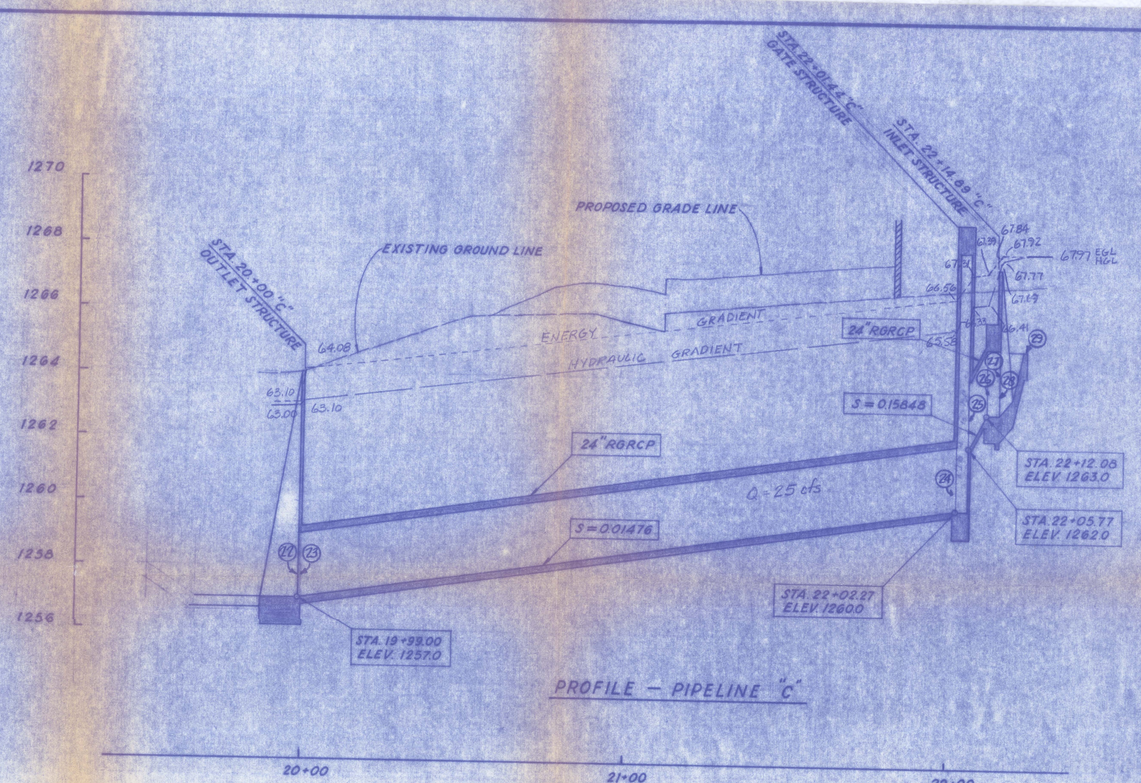
Indian Bend Wash Inlet

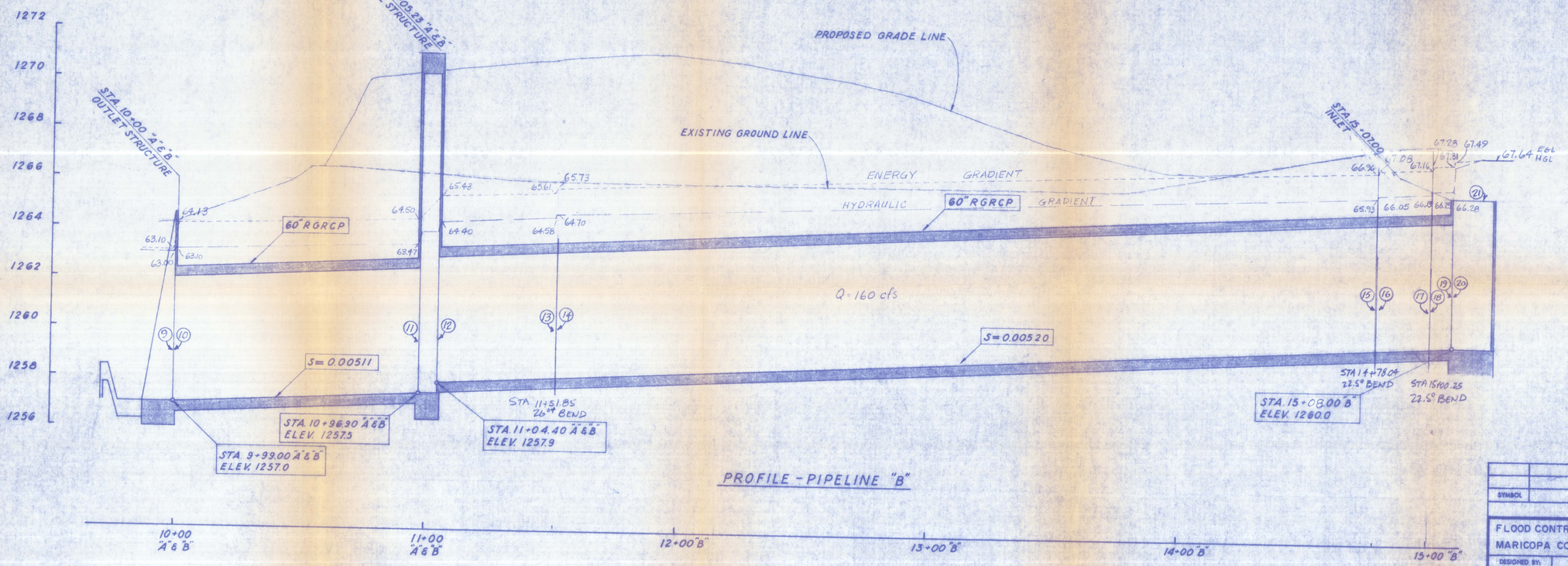
By B.J. 4-17-78

Ck

Point	Pipe "C" Station	Reach Description	Energy Grade Line Elevation	Hydraulic Grade Line Elevation	Head Loss Calculation
22	19+99 Bk		1263.10	1263.00	
		Pipe Exit			$h_{ex} = 1.0 \times 0.98' = 0.98'$
23	19+99 Ahd		1264.08	1263.10	
		203.3 L.F. 24" RGRCP			$h_f = 203.3' \times 0.01221 = 2.48'$
24	22+02.27		1266.56	1265.58	
		Flap Gate Str			$h_{str} = 0.77 \times 0.98' = 0.75'$
25	22+05.77		1267.31	1266.33	
		6.3 L.F. 24" RGRCP			$h_f = 6.3' \times 0.01221 = 0.08$
26	22+12.08	Inlet Structure	1267.39	1266.41	
		Transition Box			$h_{bend} = 0.23 \times 0.25 = 0.06'$ $h_{contr} = 0.40 \times 0.98 = 0.39'$ 0.45'
27	22+15.89 Bk	Transition Box Entrance	1267.84	1267.69	
					$h_{entr} = 0.5 \times 0.15' = 0.08'$
28	22+15.89 Ahd	Open Channel Contraction	1267.92	1267.77	
		Apron Sill to Entrance			$h_{contr} = 0.3 (0.15-0) = 0.05'$
29	22+23.89		1267.97	1267.97	
					WSE @ (29) = 1267.97
					MAX ALLOWABLE 1268.50
					- DESIGN WITHIN
					ALLOWABLE LIMITS







SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

FLOOD CONTROL DISTRICT OF MARICOPA COUNTY, ARIZONA

U. S. ARMY ENGINEER DISTRICT LOS ANGELES CORPS OF ENGINEERS

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DRAWN BY:

CHECKED BY:

GILA RIVER BASIN, ARIZONA

INDIAN BEND WASH

INLET CHANNEL

SIDE DRAIN DETAILS

VALLEY VISTA LANE PROFILES

SUBMITTED BY: CHIEF, BRANCH

APPROVED: COLONEL, C.E. DISTRICT ENGINEER

APPROVAL RECOMMENDED:

SPEC. NO. DACW09-___-B-___

DISTRICT FILE NO.

SHEET 25 OF