73-38-055 | 3/24/88

MAIN BRANCH ENERGY DISSIPATOR

$Q_{100} = 1870$ cfs

In the channel

Slope = 1.23%
n = .013
$SS_1 = SS_2 = 2:1$
Bottom Width = 10'

$y_n = 4.16'$ $y_c = 6.76'$
$V_n = 24.56$ fps $V_c = 11.76$ fps
$F = 2.56$

For 30' Grade Check

$b = 30'$
$SS_1 = SS_2 = 3:1$

$y_c = 4.25'$
$V_c = 10.29$ fps

FOR 50' Grade Check

$b = 50'$
$SS_1 = SS_2 = 3:1$
$y_c = 3.29'$
$V_c = 9.50$ fps

Find Conj. Depth in Channel

"$\bar{z}_1$" $= 1.77'$

$A_1 = 76.21$ ft^2

$$\frac{Q_1^2}{A_1 g} = 1425.00$$

$$z_1 A_1 + \frac{Q_1^2}{A_1 g} = 1559.89 = z_2 A_2 + \frac{Q_2^2}{A_2 g}$$

$$1559.89 = z_2 A_2 + \frac{108,599.38}{A_2}$$

$$z_2 A_2 = \frac{1}{3} y_2 \cancel{(2)}\cancel{(\tfrac{1}{2})} y_2 (2y_2) + \frac{1}{2} y_2 (y_2)(10)$$

$$A_2 = y_2(2y_2) + 10 y_2 = 2y_2^2 + 10 y_2$$

$$= \frac{2}{3} y_2^3 + 5 y_2^2$$

$$\therefore \quad 1559.89 = \frac{2}{3} y_2^3 + 5 y_2^2 + \frac{108,599.38}{2y_2^2 + 10 y_2}$$

$$3119.78 y_2^2 + 15598.9 y_2 = 1.33 y_2^5 + 76.67 y_2^4 + 50 y_2^3 + 108,599.3$$

$$1.33 y_2^5 + 16.67 y_2^4 + 50 y_2^3 - 3119.78 y_2^2 - 15598.9 y_2 + 108,59 = 0$$

solve for y_2; $y_2 = 10.13$

$L_{jump} = 5.8(10.13) = 58.75$ or $6.9(10.13 - 4.16) = 41.1$

$$1870 = 30(3)(H)^{3/2}$$

$$H = 7.57$$

$$1870 = 50(3)(H^{3/2})$$

$$H = 5.38$$

ANALYZE DROPS

30' GRADE CHECK

$$\frac{y_1}{\Delta Z_o} = .54\left(\frac{4.25}{3}\right)^{1.275} \Rightarrow 2.53' = y_1$$

$$\frac{y_2}{\Delta Z_o} = 1.66\left(\frac{4.25}{3}\right)^{.81} \Rightarrow y_2 = 6.60'$$

$$\frac{L_d}{DZ} = 4.3\left(\frac{4.25}{DZ}\right)^{.81} \Rightarrow 17.10' = L_d$$

$$L_j = 6.9(6.60 - 2.53) = 28.11$$

N/A

50' GRADE CHECK

$$\frac{y_1}{\Delta Z} = .54\left(\frac{3.29}{2.5}\right)^{1.275} \Rightarrow 1.92' = y_1$$

$$\frac{y_2}{DZ} = 1.66\left(\frac{3.29}{2.5}\right)^{.81} \Rightarrow 5.18' = y_2$$

$$\frac{L_d}{DZ} = 4.3\left(\frac{3.29}{2.5}\right)^{.81} \Rightarrow 13.43' = L_d$$

$$L_j = 6.9(5.37-1.82) \Rightarrow 22.49' = L_j$$

SUMMARY OF FLOW CALCULATIONS FOR MAIN BRANCH CHANNEL

NOTE: 105 cfs is added to ~~all~~ Main Br. flows shown on Master Drainage Plan because this is 100 yr. run-off at time of peak from the diversion around Shenandoah Units II + III. THIS applies to flows east of Golf Course Road.

STATION 27+50 to 39+87

RECEIVED
SEP 02 1988
HYDROLOGY SECTION

Q_{100} = 1169 cfs
Slope = 2.68%
Side Slopes = 2:1
Bottom Width = 10'
Use n = .013

D_n = 2.68'
V_n = 28.47 fps
F = 3.56

Min Radius = 720.0'

$$\text{Super Elevation}(s) = \frac{1.3\,(28.47)^2\,(10 + 2(2)(2.68))}{g\,(720)}$$

$$= 0.94'$$

$$\text{Req'd freeboard} = .7(2 + .025(28.47)(2.68)^{1/3})$$

$$= 2.09'$$

Total Req'd depth = 2.68 + .94 + 2.09 = 5.71'

say 6'

STATION 26+00 to 27+50

Q_{100} = 1169 cfs
Slope = 3.62%
Sideslopes = 2:1
Bottom Width = 10'
Use n = .013

D_n = 2.47'
V_n = 31.67 fps
F = 4.10

Req'd Freeboard = $.7(2+.025(31.67)(4.10)^{1/3})$
= 2.29'

Total Req'd Depth = 2.47 + 2.29 = 4.76'
6', OK

STATION 12+50 to 22+81

Q_{100} = 1607+105 = 1712 cfs
Slope = 2.23%
Sideslopes = 2:1
Bottom Width = 10'
n = .013

D_n = 3.43'
V_n = 29.63 fps
F = 3.35

MIN Radius = 1126.65

Super Elevation (s) = $\dfrac{1.3\,(29.63)^2\,(10+2(2)3.43)}{g(1126.65)}$

= 0.75'

Req'd Freeboard = $.7(2+.025(29.63)(3.43)^{1/3})$

= 2.18'

TOTAL REQ'D DEPTH = 3.43 + 0.75 + 2.18 = 6.36'
say 6.5'

STATION 10+92 to 12+50

Q_{100} = 1712 cfs
Slope = 1.23%
Sideslopes = 2:1
Bottom Width = 10'
n = .013

D_n = 3.99'
V_n = 23.89 fps
F = 2.53

Req'd Freeboard = $.7(2+.025(23.89)(3.99)^{1/3})$ = 2.06

TOTAL REQ'D DEPTH 3.99 + 2.06 = 6.05
6.5', OK

STA 6+00 to 10+92

$Q_{100} = 1870 + 105 = 1975$ cfs
Slope = 1975 cfs
Sideslopes = 2:1
Bottom Width = 10'
$n = .013$

$D_n = 4.28'$
$V_n = 24.83$ fps
$F = 2.56$

MIN. Radius = 1488.05'

Super Elevation = $\dfrac{1.3\,(24.83)^2\,(10 + 2(2)(4.28))}{g\,(1488.05)}$
$= 0.46$

Req'd Freeboard = $.7(2 + .025(24.47)(4.17)^{1/3})$
$= 2.11$

TOTAL REQ'D DEPTH = $4.28 + .46 + 2.11 = \underline{\underline{6.85'}}$

say 7'

Summer '87

73-38-054

1-14-88

RECEIVED
SEP 02 1988
HYDROLOGY SECTION

Revised due to Channel/Bride changing from a 1.5:1 to a 2:1 side slopes

COMPUTATIONS

$\Delta = 1.40 - 1.14 = .16'$

FOR MAIN BRANCH PIEDRAS MARCADAS JUNCTION @ GOLF COURSE ROAD

ANALYSIS

66" PIPE NORTH OF NORTH BRANCH

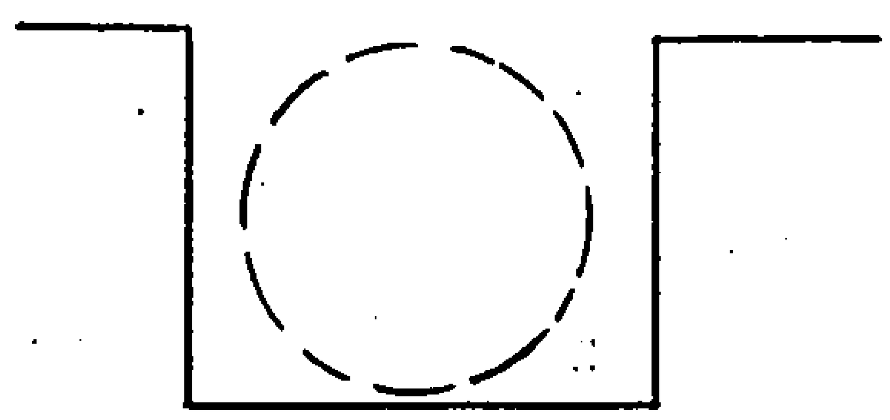
$Q = 350\,\text{cfs}$ $\quad \phi = 66''$ $\quad n = 0.013$ $\quad S = \dfrac{9}{388'} = 0.023$

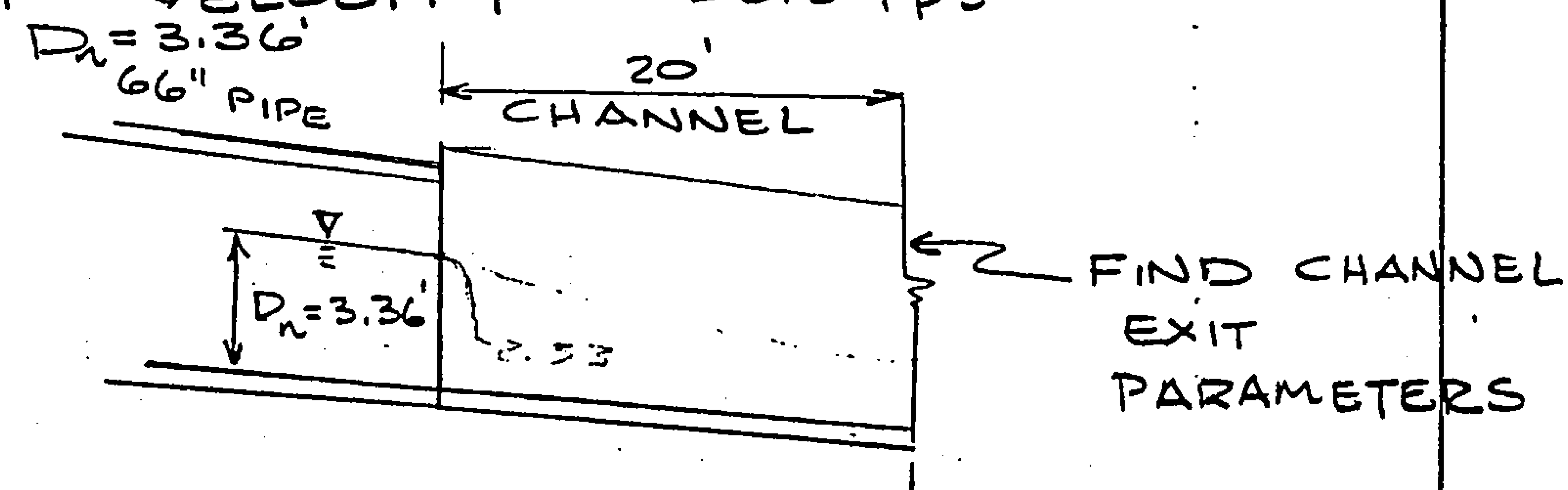
$\rightarrow D_n = 3.36$ $\quad V_n = 23.2\,\text{fps}$ $\quad F = 2.43$

$Y_c = 5.02'$

ASSUME NO LOSSES IN MOMENTUM
BECAUSE OF RADIUS PIPE AND 390' LENGTH
TO FLOW INTO NORMAL DEPTH

ASSUME EXIT VELOCITY = 23.2 fps
IN PIPE

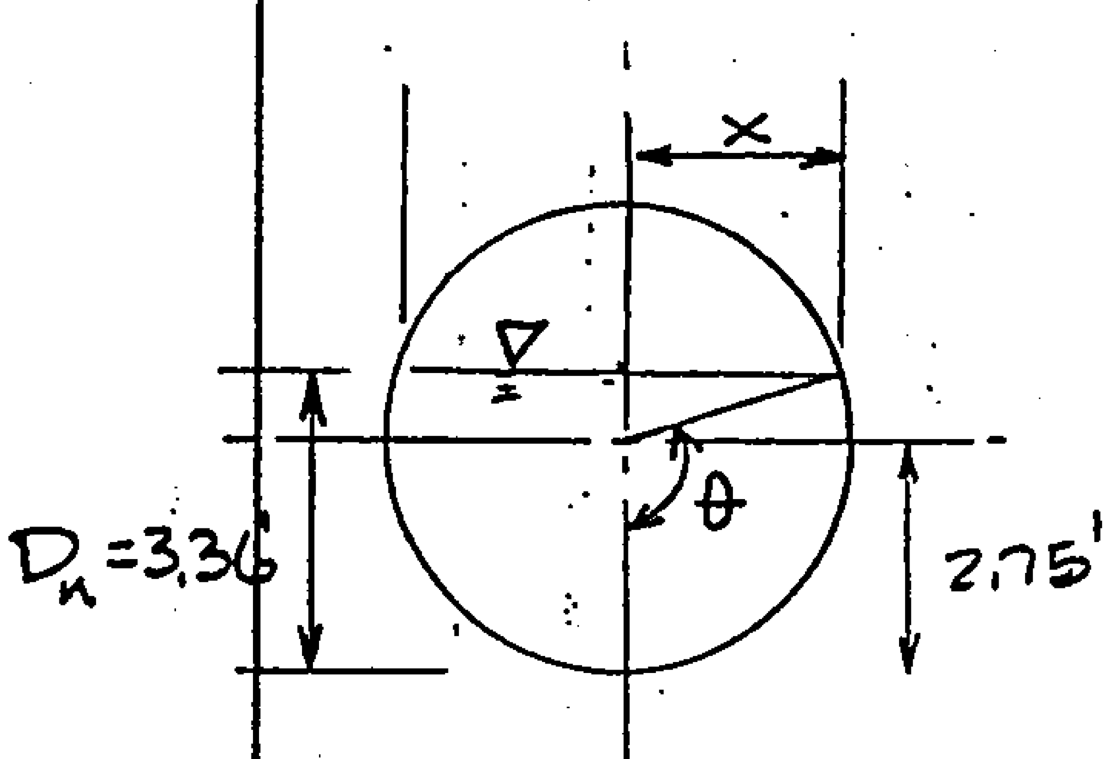




$Q = 350\,\text{cfs}$ $\quad n = 0.015$ $\quad S = 0.023$ $\quad SS_1 = 0$

$SS_2 = 0$ $\quad W = 6.5'$ $\quad D_1 = ?$ $\quad D_2 = 0$

$D_n = 2.73$ $\quad V = 19.70\,\text{fps}$ $\quad F = 2.10$

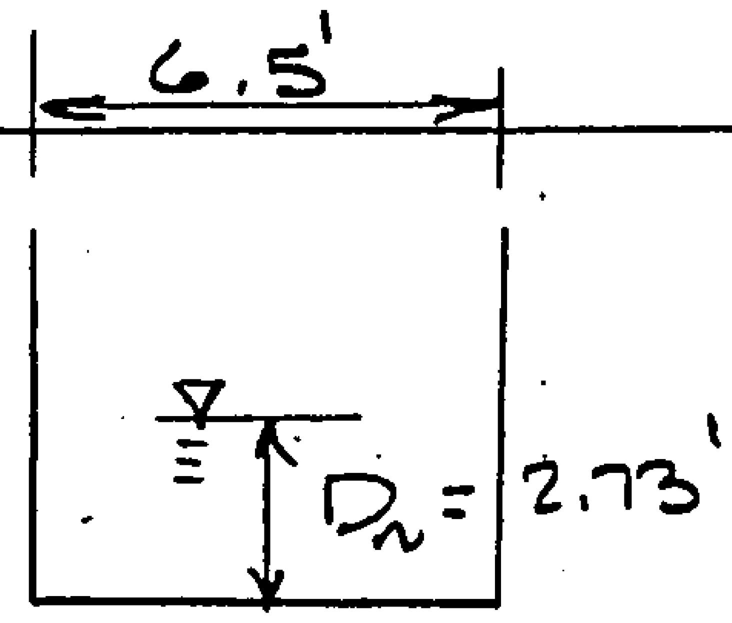


$$\theta_{PIPE} = 180 - \cos^{-1}\left(\frac{3.36 - 2.75}{2.75}\right) = 102.82^\circ$$

$$X_{PIPE} = \left((2.75')^2 - (3.36 - 2.75)^2\right)^{1/2} = 2.68'$$

$$A_{PIPE} = \frac{2(102.82^\circ)}{360^\circ}\pi(2.75')^2 + (2.68')(0.61') = 15.21\,\text{ft}^2$$

$$R_{PIPE} = \frac{15.21}{\frac{2(102.82^\circ)}{360}\pi(5.5)} = 1.54$$



CHANNEL @ NORMAL

$A_{CH} = 6.5'(2.73') = 17.75\,ft^2$

$R_{CH} = \dfrac{17.75}{2(2.73)+6.50} = 1.48$

$V_m = \dfrac{V_{PIPE} + V_{CH}}{2} = \dfrac{23.2 + 19.70}{2} = 21.45$

$R_m = \dfrac{R_{PIPE} + R_{CH}}{2} = \dfrac{1.54 + 1.48}{2} = 1.51$

$E_1 = y_{PIPE} + \dfrac{(V_{PIPE})^2}{2g} = 3.36 + \dfrac{(23.2)^2}{2(32.2)} = 11.72$

$E_2 = y_{CH} + \dfrac{V_{CH}^2}{2g} = 2.73 + \dfrac{(19.70)^2}{2(32.2)} = 8.76$

$L = \dfrac{E_1 - E_2}{\left(\dfrac{n\,V_m}{1.49\,R_m^{2/3}}\right)^{1/2} - S_0} = \dfrac{11.72 - 8.76}{\left(\dfrac{0.015\,(21.45)}{1.49\,(1.51)^{2/3}}\right)^2 - 0.023} = 770'$

PRORATE @ L = 20' CHANNEL EXIT

$V_{20} = 23.2 - \dfrac{20}{770}(23.2 - 19.70) = 23.10\,fps$

MANNINGS EQ

$Q = 350$ $V = 23.10\,fps \longrightarrow D_{20} = 2.33'$

@ CHANNEL EXIT

PROVIDE SMOOTH TRANSITION FROM PIPE TO CHANNEL IN 20' TO REDUCE LOSSES

$Q = 174\,\text{CFS}$ $d = 54''$ $n = 0.013$ $S = \frac{5}{410} = 0.0122$

$\rightarrow$ $D_n = 3.06$ $V_n = 15.23$ $F = 1.62$

$D_c = 3.83'$

$Q = 174\,\text{CFS}$ $d = 48''$ $n = 0.013$ $S = \frac{3}{90} = 0.0333$

$\rightarrow D_n = 2.39$ $V_n = 22.40$ $F = 2.79$

$D_c = 3.75'$

$$\theta_c = 180 - \cos^{-1}\left(\frac{3.75 - 2.0}{2.0}\right) = 151.05^\circ$$

$$X_c = \left((2.0)^2 - (3.75 - 2.0)^2\right)^{1/2} = 0.97'$$

$$A_c = \frac{2(151.05^\circ)}{360^\circ}\pi(2.0')^2 + 0.97'(1.75') = 12.24\ \text{ft}^2$$

$$V_c = \frac{Q}{A_c} = \frac{174}{12.24} = 14.2\ \text{fps} < 15.23\ \text{fps}$$

ASSUME FLOW THRU MANHOLE AT 74+00 LEAVES @ CRITICAL DEPTH

DETERMINE PARAMETERS @ EXIT OF PIPE

$$R_c = \frac{A_c}{W.P.} = \frac{12.24}{\frac{2(151.05^\circ)}{360}\pi \times 4'} = 1.16$$

$$\theta_n = 180 - \cos^{-1}\left(\frac{2.39 - 2.00}{2.00}\right) = 101.24^\circ$$

$$X_n = \left((2.0)^2 - (2.39 - 2.00)^2\right)^{1/2} = 1.96'$$

$$A_n = \frac{2(101.24^\circ)}{360}\pi(2.0)^2 + 1.96'(0.39') = 7.83\ \text{ft}^2$$

$$R_n = \frac{A_n}{W.P.} = \frac{7.83}{\frac{2(101.24)}{360}\pi \cdot 4} = 1.11$$

$$R_m = \frac{R_n + R_c}{2} = \frac{1.16 + 1.11}{2} = 1.13$$

$$V_m = \frac{V_n + V_c}{2} = \frac{22.40 + 14.20}{2} = 18.3 \text{ fps}$$

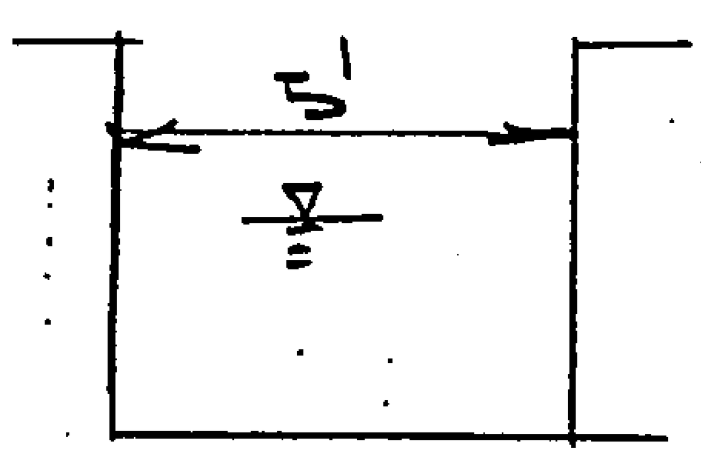
$$E_1 = y_c + \frac{V_c^2}{2g} = 3.75 + \frac{(14.2)^2}{2(32.2)} = 6.88$$

$$E_2 = y_n + \frac{V_n^2}{2g} = 2.39 + \frac{(22.40)^2}{2(32.2)} = 10.18$$

$$L = \frac{E_1 - E_2}{\left(\frac{n V_m}{1.49 R_m^{2/3}}\right)^2 - S_o} = \frac{6.88 - 10.18}{\left(\frac{0.013(18.3)}{1.49(1.13)^{2/3}}\right)^2 - 0.033} = \underline{\underline{290'}}$$

PRORATE PIPE EXIT @ L = 70'

$$V_{\substack{\text{PIPE}\\\text{EXIT}}} = 14.2 + \frac{70}{290}(22.40 - 14.20) = \underline{\underline{16.2 \text{ fps}}}$$



SIDECHANNEL @ NORMAL CONDITIONS

$Q = 174$ $n = 0.015$ $S = 0.033$ $SS_1 = 0$

$SS_2 = 0$ $W = 5'$ $D_1 = ?$ $D_2 =$

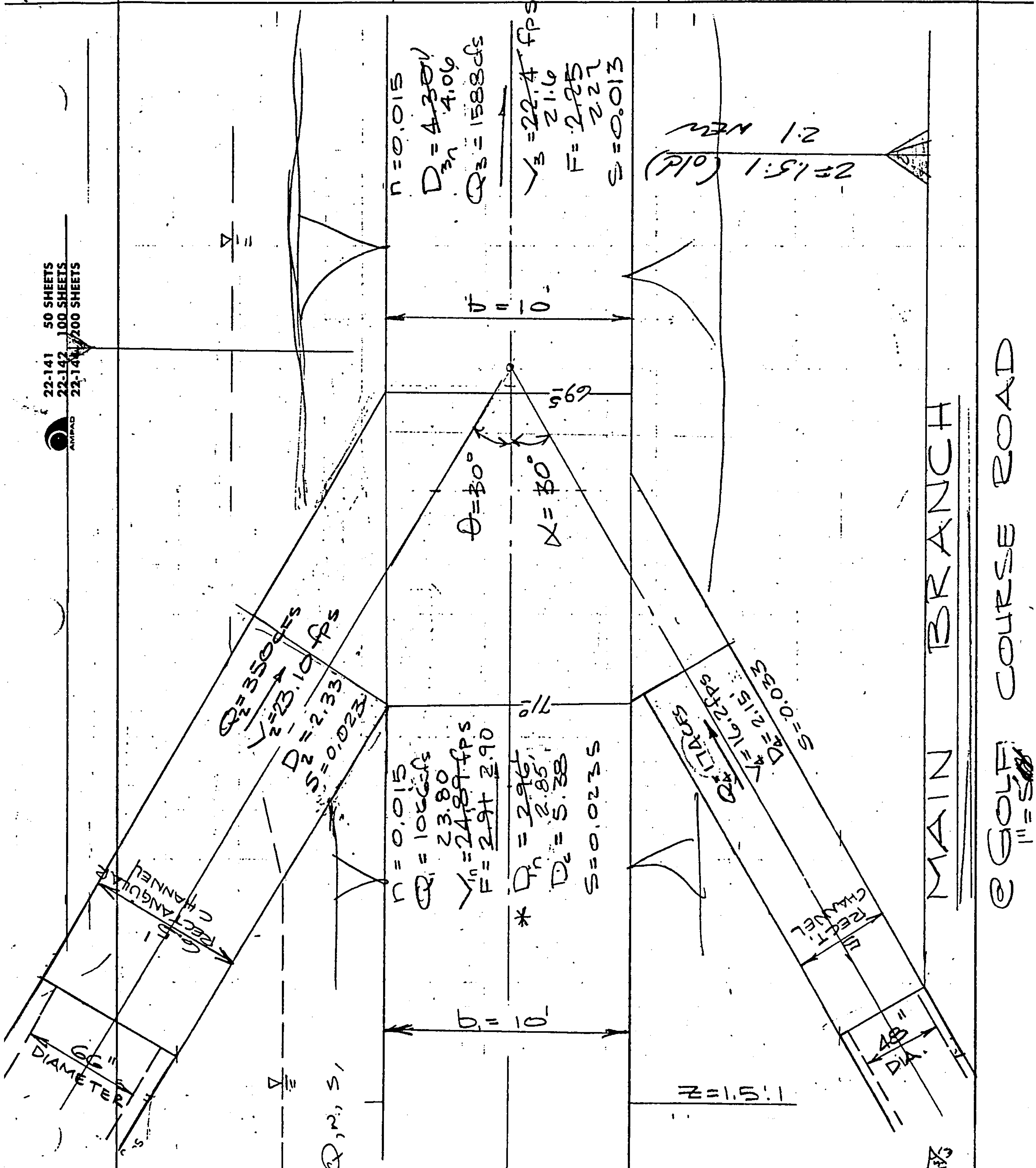
$\rightarrow D_1 = 1.86'$ $V_n = 18.7$ fps $F = 2.42$

SINCE NOT VELOCITY CHANGE FROM PIPE TO CHANNEL ASSUME
$V = 16.2$ fps @ CHANNEL EXIT @ $\underline{\underline{20'}}$
FROM MANNINGS

$Q = 174$ CFS $V = 16.2$ fps

$\rightarrow D_{2b} = 2.15'$

PROVIDE SMOOTH TRANSITION FROM PIPE TO CHANNEL TO REDUCE LOSSES



* #'s to be used in Equilibrium Equation

EQUILIBRIUM EQUATION

$$P_3 + M_3 = P_1 + M_1 + M_2 \cos\theta + M_4 \cos\alpha + P_L + P_w - P_f$$

$$M_1 = \frac{Q_1^2}{(b_1 + z d_1) g d_1}$$

$$M_2 \cos\theta = \frac{Q_2^2}{b_2 d_{c_2} g} \cos\theta$$

$$M_3 = \frac{Q_3^2}{(b_3 + z d_3) g d_3}$$

$$M_4 \cos\alpha = \frac{Q_4^2}{b_4 d_{c_4} g} \cos\alpha$$

$$P_1 = \frac{d_1^2}{6}(3b_1 + 2 z d_1)$$

$$P_3 = \frac{d_3^2}{6}(3b_3 + 2 z d_3)$$

$$P_L = \left(\frac{b_1 + b_3}{2}\right) h \left[d_1 + \frac{(d_3 - d_1)(b_1 + 2b_3)}{3(b_1 + b_3)}\right]$$

$$P_w = \frac{d_1 + d_3}{4}\left[\frac{b_1 + b_3}{2}(d_1 - d_3) + h'(z d_1 + z d_3) + (b_3 + z d_3) d_3 - (b_1 + z d_1) d_1\right]$$

$$P_f = \frac{L(S_1 + S_2)}{4}\left[(b_1 + z d_1) d_1 + (b_3 + z d_3) d_3\right]$$

EQUILIBRIUM EQ @ $t = 250$ min

SOLVE FOR $h = z$

$$M_1 = \frac{Q_1^2}{(b+zd_1)d_1 g} = \frac{(1066)^2}{\left(10+\underset{2.0}{\cancel{1.5}}(\underset{2.85}{\cancel{2.96}})\right)\underset{2.85}{\cancel{2.96}}(32.2)} = \cancel{825.7}\ 788.7$$

$$M_2\cos\theta = \frac{Q_2^2}{b_2 d_2 g}\cos\theta = \frac{(350)^2}{6.5(2.33)32.2}\cos 30^\circ = 217.5$$

$$M_3 = \frac{Q_3^2}{(b+zd_3)d_3 g} = \frac{(1588)^2}{\left(10+\underset{2.0}{\cancel{1.5}}(\underset{4.06}{\cancel{4.30}})\right)\underset{4.06}{\cancel{4.30}}(32.2)} = \cancel{1107.2}\ 1064.5$$

$$M_4\cos\theta = \frac{Q_4^2}{b_4 d_4 g}\cos\theta = \frac{(174)^2}{5'(2.15')32.2}\cos 30^\circ = 75.7$$

$$P_1 = \frac{\overset{2.85}{\cancel{(2.96)}}^2}{6}\left(3(10) + 2(\overset{2.0}{\cancel{1.5}})\overset{2.85}{2.96'}\right) = \cancel{56.8}\ 56.0$$

$$P_3 = \frac{\overset{(4.06)}{\cancel{(4.30)}}^2}{6}\left(3(10) + 2(\overset{2.0}{\cancel{1.5}})\overset{4.06}{\cancel{4.30}}\right) = \cancel{132.2}\ 127.0$$

$$P_L = \left(\frac{10+10}{2}\right)z\left[\overset{2.85}{\cancel{2.96}} + \frac{(\overset{4.06-2.85}{\cancel{4.30-2.96}})(10+2(10))}{3(10+10)}\right] = \cancel{36.3z}\ 34.6z$$

$d_1 = 2.85$
$d_3 = 4.06$

$$P_w = \frac{\overset{2.85+4.06}{\cancel{2.96+4.30}}}{4}\left[\frac{10+10}{2}\overset{-12.1}{(\overset{2.85-4.06}{\cancel{2.96-4.30}})} + \overset{73.57}{\left(10+\overset{2.0}{\cancel{1.5}}(\overset{4.86}{\cancel{4.30}})\right)\overset{4.06}{\cancel{4.30}}} - \overset{44.75}{\left(10+\overset{2.0}{\cancel{1.5}}(\overset{2.85}{\cancel{2.96}})\right)\overset{2.85}{\cancel{2.96}}}\right]$$

$P_w = \cancel{26.5}\ 28.88$

11.832

$$P_f = \frac{\overset{15.16}{\cancel{13}}(0.0235+0.013)}{4}\left[\overset{44.75}{\left(10+\overset{2.0}{\cancel{1.5}}(\overset{2.85}{\cancel{2.96}})\right)\overset{2.85}{\cancel{2.96}}} + \overset{73.57}{\left(10+\overset{2.0}{\cancel{1.5}}(\overset{4.06}{\cancel{4.30}})\right)\overset{(4.06)}{4.30}}\right]$$

$P_f = \cancel{13.46}\ 14.09$

$1064.5 + 127.0 = 788 + 217.5 + 75.7 + 56.0 + 34.6z + 28.88 - 14.09$

$\cancel{1107.2} + \cancel{132.2} = \cancel{825.7} + \cancel{217.5} + \cancel{75.7} + \cancel{56.8} + \cancel{36.3z} + \cancel{26.5} - 13.46$

$z = \overset{1.14'}{\cancel{1.40}}$ say $\overset{1.20' \rightarrow 1.2}{\cancel{1.50}}$ .31

$\Delta y = z + d_1 - d_2 = \cancel{1.50'} + \cancel{2.96'} - 4.30' = \cancel{0.16'}$

$1.20' + 2.85 - 4.06 = 0.01 \rightarrow$ OK