THE FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

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FINAL DESIGN AND QUANTITY CALCULATIONS

WHITE TANKS NO. 4 FRS INLET IMPROVEMENTS

FCD NO. 92-38

Registered Professional Engineer (Civil)
CERTIFICATE NO.
24433
KENNETH L.
SNYDER
Date Signed 10/28/94
ARIZONA, U. S. A.

Kenneth L. Snyder

DIBBLE & ASSOCIATES
CONSULTING ENGINEERS

3625 NORTH 16TH STREET, SUITE 128
PHOENIX, ARIZONA 85016-6443

OCTOBER 28, 1994

THE FLOOD CONTROL DISTRICT OF MARICOPA COUNTY
WHITE TANKS NO. 4 FRS INLET IMPROVEMENTS
FCD NO. 92-38

FINAL DESIGN AND QUANTITY CALCULATIONS

HYDRAULICS CALCULATIONS	
Drop Inlet Hydraulics, Sta. 15+60	6 PAGES
Drop Inlet Hydraulics, Sta. 29+00	6 PAGES
Drop Inlet Hydraulics, Sta. 41+75	6 PAGES
Drop Inlet Hydraulics, Sta. 51+80	6 PAGES
Drop Inlet Hydraulics, Sta. 59+00	6 PAGES
Drop Inlet References	19 PAGES
HEC-2 Input, Subcritical Flow	10 PAGES
HEC-2 Output (Summary Tables), Subcritical Flow	25 PAGES
HEC-2 Input, Supercritical Flow	10 PAGES
HEC-2 Output (Summary Tables), Supercritical Flow	26 PAGES
ENGINEER'S ESTIMATE	2 PAGES
QUANTITY SUMMARY	1 PAGE
MISCELLANEOUS QUANTITIES	1 PAGE
SLOPE LINER QUANTITIES	3 PAGES
ROADWAY BASE QUANTITIES	1 PAGE
EARTHWORK QUANTITIES	10 PAGES

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DIBBLE AND ASSOCIATES CONSULTING ENGINEERS

THE FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

FINAL HYDRAULICS CALCULATIONS

DIBBLE AND ASSOCIATES CONSULTING ENGINEERS

THE FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

DROP INLET HYDRAULICS - STA. 15+60

DIBBLE AND ASSOCIATES CONSULTING ENGINEERS

White Tanks #4 FRS Channel - Sta 15+60
CHANNEL HYDRAULICS CHARACTERISTICS

Trapizoidal Channel

```
**            T              **
 **-------------------------**
  **          6.28         **
Za **       FT DEEP      ** Zb
    **                  **
     ******************
              B
```

Q =	2206.0	cfs
So =	0.0008	ft/ft
n =	0.028	
B =	65	ft
Za =	2 : 1	
Zb =	2 : 1	
Zave =	2.00 : 1	
g =	32.175	ft/sec^2

TRIAL DEPTH = 6.2838104 ft

NORMAL FLOW CALCULATIONS:

flow (Qn) =	2206.0	cfs
depth (dn) =	6.28	ft
velocity (Vn) =	4.53	fps
Froude # (Fn) =	0.343	

CRITICAL FLOW CALCULATIONS:

depth (dc) =	3.186	ft
velocity (Vc) =	9.70	fps
slope (Sc) =	0.008194	ft/ft

Vc^2/g-Ac/Tc = 0.00000
(Equals 0 at Critical Depth)

For normal depth calcs:

An =	487.420	sq ft
Pn =	93.102	ft
Rn =	5.235	ft
Tn =	90.135	ft

For critical depth calcs:

Ac =	227.398	sq ft
Pc =	79.249	ft
Rc =	2.869	ft
Tc =	77.744	ft

SEQUENT DEPTH CALCULATIONS:

ds =	NA	
As =	NA	sq ft
Ps =	NA	ft
Rs =	NA	ft
Ts =	NA	ft
Vs =	NA	fps
Froude # (Fs) =	NA	

(Formulas for hydraulic jumps in trapazoidal channels are from FHWA's "Hydraulic Design of Energy Dissipators for Culverts and Channels, HEC No. 14, p.VI-8)

ds_t =	NA
t = B/z/dn =	NA
J = ds_t/dn =	NA
Fn - Fjump =	NA (= 0)

(Equals 0 at sequent depth)

GRADE CONTROL STRUCTURE - STA 15+60
DROP SPILLWAY

Given:

Q =	2206	cfs	
n =	0.028		(Manning's n factor)
g =	32.175	ft/sec/sec	(gravitational constant)

Drop approach conditions: From HEC-2 SECNO 1580

ya =	3.65	ft	(depth of flow)
va =	8.36	fps	(velocity)
hva =	1.09	ft	(velocity head)
Soa =	0.0008	ft/ft	(channel slope)

D R O P G E O M E T R Y

	Sta	Elev	B	Za	Zb	Zave
Section 0	15+60	44.83	65.00	2.00	2.00	2.00
Section 1	15+50	41.58	65.00	2.00	2.00	2.00
Section 2	15+18	41.56	70.81	3.16	2.00	2.58

Drop Width = 65.00
Drop Height = 3.25

Calculate critial flow parameters for Section 0:

Solution is by trail and error.

yc =	3.186	ft	(critical depth)
Sc =	0.0082	ft/ft	(critical slope)
Vc =	9.70	fps	(critical velocity)
Ac =	227.40	sq ft	(cross sectional area of flow)
Pc =	79.25	ft	(wetted perimeter)
Rc =	2.87	ft	(hydraulic radius)
Tc =	77.74	ft	(top of water surface width)

Vc^2/g-Ac/Tc = 0.000 (= 0 at correct Critical Depth)

GRADE CONTROL STRUCTURE - STA 15+60
DROP SPILLWAY

Method used for trapaziodal drop spillway design.

Note: The references used are noted in the appropriate locations in the calculations that follow.

The following steps are used in the analysis:

1. The parameters for a straight rectangular drop spillway are calculated.

2. Brink conditions are calculated at the top of the drop.

3. The trapeziodal drop spillway design is as follows.

   a. These calculations assume a free falling nappe. Therefore, the drop height must be greater than or equal to the depth of the pool, yp, at the bottom of the drop. Use the value of yp calculated above for a rectangular straight drop spillway.
   b. Energy is balanced between the Approach Section and Section 1 at the bottom of the drop assuming no energy loss in the drop. That is, the energy grade elevation at the Approach Section and Section 1 are equal. The solution is by trial and error.
   c. Hydraulic jump equations are used to solve for the conjugate depth at Section 2. The solution is by trial and error.
   d. A straight line is assumed between the centroid of the water on the brink, the intersection of the nappe with the pool under the nappe and the bottom of the pool at Section 1.
   e. The distance from the brink to the intersection of the nappe with the pool under the nappe is calculated. The formula for a free falling object,
      $$y = v0 * t + 0.5 * g * t^2$$
      is used to calculate the time required for the water to fall to the top of the pool. The horizontal distance the water traveled is then calculated using this time. An initial vertical velocity, v0, of 0 and a horizontal velocity equal to the brink velocity, vb, is assumed.
   f. The line from the brink to the intersection of the nappe with the pool is then extended to the bottom of the pool. This defines the location of Section 1.

GRADE CONTROL STRUCTURE - STA 15+60
DROP SPILLWAY

g. The length of the hydraulic jump is calculated using the equation Ljump = 6.9 * (y2 - y1), where y1 is the depth at section 1 and y2 is the conjugate depth at Section 2.

4. The height of the end sill required to contain the hydraulic jump is calculated. That is, the sill is designed so that the depth upstream of the sill is greater than or equal to the conjugate depth at Section 2. The effect of submergence caused by high tailwater is considered if required.

Calculate design for rectangular straight drop spillway.

Reference: Chow, Ven Te, "Open Channel Hydraulics," McGraw-Hill, 1959. (pp. 423-425).

D =	(Q/B)^2 / g / Drop^3 =	1.04
Ld =	4.30 * D^0.270 * Drop =	14.13
yp =	1.00 * D^0.220 * Drop =	3.28
y1 =	0.54 * D^0.425 * Drop =	1.79
y2 =	1.66 * D^0.270 * Drop =	5.46

Calculate brink conditions at the top of the drop:

Reference: Blevins, Robert D. "Applied Fluid Dynamics Handbook," Van Nostrand Reinhold, 1984. (pp. 208-209)

The depth at the brink is a function of the approach channel slope Soa and the channel slope required for critical flow Sc.

T A B L E O F B R I N K F A C T O R S (From Reference)

Soa/Sc	-6.00	-4.00	-2.00	0.00	1.00	2.00	4.00	6.00
db/dc	0.750	0.745	0.730	0.715	0.680	0.650	0.575	0.525

Soa/Sc =	0.10	(approach slope / critical slope)
db/dc =	0.712	(brink factor)
db =	2.27 ft	(brink depth)
vb =	13.99 fps	(brink velocity)

GRADE CONTROL STRUCTURE - STA 15+60
DROP SPILLWAY

Calculate design for a trapaziodal drop spillway with lined floor:

Reference: Agostini, R., A. Bizzarri & M. Masetti, "Flexible Structures in River and Stream Training Works," S.P.A. Officine Maccaferri, Bologna, 1981. (pp. 34-37 and 52-54)

	y (ft)	v (fps)	hv (ft)	A (sq ft)	T (ft)	Fr	EG (ft)
Approach	3.65	8.36	1.09	263.90	79.60	0.81	49.57
Section 1	1.60	20.28	6.39	108.78	71.38	2.90	49.57
Section 2	5.56	4.66	0.34	473.22	99.49	0.38	47.46

Conjugate depth calculations at Section 2 are based on hydraulic depth. (Reference: Blevins, Robert D., "Applied Fluid Dynamics Handbook," Van Nostrand Reinhold, 1984. p.196)

alpha = 1.12 (working variable for equation)
beta = 0.96 (working variable for equation)

Conjugate depth equation
0.000 (= 0 when correct sequent depth is obtained)

db/2 elev = 45.96 ft (water centroid elev at brink)
yp elev = 44.86 ft (elev of pool at bottom of drop)
Fall_p = 1.10 ft (vertical fall - centroid to yp)
Fall_1 = 4.38 ft (vertical fall - centroid to floor)

L_p = 3.66 ft (horiz distance - brink to yp)
L_1 = 14.56 ft (horiz distance - brink to y1)
L_2 = 27.34 ft (horiz dist - y1 to y2, jump length

As a check, calculate weir equation coefficient for design

Weir formula: $Q = C * B * H^{1.5}$

H = 4.74 ft (head on weir, H = ya + hva)
C = 3.29 (equiv weir coeff, C = Q / L / H^1.5)
yc/H = 0.673 ==> OK, (should = approx 2/3)

GRADE CONTROL STRUCTURE - STA 15+60
DROP SPILLWAY

Calculate height of sill required at end of stilling basin:
(Note: A rectangular channel is assumed for sill calculations.)

Reference: Blevins, Robert D. "Applied Fluid Dynamics Handbook," Van Nostrand Reinhold, 1984. (pp. 201-206)]

Sill formula:

$$Qsill = (2/3)^{1.5} * Csill * Bsill * g^{0.5} * (ha + Va/2/g)^{1.5}$$

where:

Csill = 0.848*F
F = function of ha/Lsill and ha/(ha+hb)

The formula is solved by trial and error for Q.

y2 =	5.56	ft	(sequent depth at Section 2)
Bsill =	70.81	ft	(width of rectangular channel)
hbmin =	1.67		(min sill height req'd, ha+hb = y2)
hb =	1.70	ft	(sill height)
ha =	3.90	ft	(height of water above top of sill)
ha+hb =	5.60	ft	==> OK, (ha+hb > y2, jump contained
Lsill =	2.00	ft	
ha/Lsill =	1.95		
ha/(ha+hb) =	0.70		
F =	1.30		
Csill =	1.10		
Vsill =	5.57	fps	(assuming a rectangular channel)
hvsill =	0.48	ft	(assuming a rectangular channel)
Qsill =	2206	cfs	

Equivalent sill weir coefficient C = 3.40

Check for submergence of sill -
Tailwater conditions: From HEC-2 SECNO 1495

y3 =	4.78	ft	(tailwater depth)
hc =	3.08	ft	(height of tailwater above sill)
hc/ha =	0.79		==> OK, (hc/ha < 0.80)
Qdrown =	1.000		(sill not submerged)
Qadj =	2206	cfs	(sill not submerged, Qadj = Qsill)

THE FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

DROP INLET HYDRAULICS - STA. 29+00

DIBBLE AND ASSOCIATES CONSULTING ENGINEERS

White Tanks #4 FRS Channel - Sta 29+00
CHANNEL HYDRAULICS CHARACTERISTICS

Trapizoidal Channel

```
**            T              **
 **-------------------------**
  **          3.55         **
Za **       FT DEEP      ** Zb
    **                  **
     ******************
              B
```

Q =	2206.0	cfs
So =	0.005	ft/ft
n =	0.015	
B =	36	ft
Za =	2	: 1
Zb =	2	: 1
Zave =	2.00	: 1
g =	32.175	ft/sec^2

TRIAL DEPTH = 3.5515454 ft

NORMAL FLOW CALCULATIONS:

flow (Qn) =	2206.0	cfs
depth (dn) =	3.55	ft
velocity (Vn) =	14.41	fps
Froude # (Fn) =	1.455	

CRITICAL FLOW CALCULATIONS:

depth (dc) =	4.477	ft
velocity (Vc) =	10.96	fps
slope (Sc) =	0.002224	ft/ft

Vc^2/g-Ac/Tc = 0.00000
(Equals 0 at Critical Depth)

For normal depth calcs:

An =	153.083	sq ft
Pn =	51.883	ft
Rn =	2.951	ft
Tn =	50.206	ft

For critical depth calcs:

Ac =	201.273	sq ft
Pc =	56.023	ft
Rc =	3.593	ft
Tc =	53.909	ft

SEQUENT DEPTH CALCULATIONS:

ds =	5.534	
As =	260.484	sq ft
Ps =	60.750	ft
Rs =	4.288	ft
Ts =	58.137	ft
Vs =	8.469	fps
Froude # (Fs) =	0.705	

(Formulas for hydraulic jumps in trapazoidal channels are from FHWA's "Hydraulic Design of Energy Dissipators for Culverts and Channels, HEC No. 14, p.VI-8)

ds_t =	5.534	
t = B/z/dn =	5.068	
J = ds_t/dn =	1.558	
Fn - Fjump =	0.000	(= 0)

(Equals 0 at sequent depth)

GRADE CONTROL STRUCTURE - STA 29+00
DROP SPILLWAY

Given:

Q =	2206 cfs	
n =	0.015	(Manning's n factor)
g =	32.175 ft/sec/sec	(gravitational constant)

Drop approach conditions: From HEC-2 SECNO 2950

ya =	3.55 ft	(depth of flow)
va =	14.42 fps	(velocity)
hva =	3.23 ft	(velocity head)
Soa =	0.0050 ft/ft	(channel slope)

D R O P G E O M E T R Y

	Sta	Elev	B	Za	Zb	Zave
Section 0	29+00	51.56	36.00	2.00	2.00	2.00
Section 1	28+85	46.56	36.00	2.00	2.00	2.00
Section 2	28+37	46.49	36.00	2.00	2.00	2.00

Drop Width = 36.00
Drop Height = 5.00

Calculate critial flow parameters for Section 0:

Solution is by trail and error.

yc =	4.477 ft	(critical depth)
Sc =	0.0022 ft/ft	(critical slope)
Vc =	10.96 fps	(critical velocity)
Ac =	201.27 sq ft	(cross sectional area of flow)
Pc =	56.02 ft	(wetted perimeter)
Rc =	3.59 ft	(hydraulic radius)
Tc =	53.91 ft	(top of water surface width)

Vc^2/g-Ac/Tc =-0.000 (= 0 at correct Critical Depth)

GRADE CONTROL STRUCTURE - STA 29+00
DROP SPILLWAY

Method used for trapaziodal drop spillway design.

Note: The references used are noted in the appropriate locations in the calculations that follow.

The following steps are used in the analysis:

1. The parameters for a straight rectangular drop spillway are calculated.

2. Brink conditions are calculated at the top of the drop.

3. The trapeziodal drop spillway design is as follows.

   a. These calculations assume a free falling nappe. Therefore, the drop height must be greater than or equal to the depth of the pool, yp, at the bottom of the drop. Use the value of yp calculated above for a rectangular straight drop spillway.
   b. Energy is balanced between the Approach Section and Section 1 at the bottom of the drop assuming no energy loss in the drop. That is, the energy grade elevation at the Approach Section and Section 1 are equal. The solution is by trial and error.
   c. Hydraulic jump equations are used to solve for the conjugate depth at Section 2. The solution is by trial and error.
   d. A straight line is assumed between the centroid of the water on the brink, the intersection of the nappe with the pool under the nappe and the bottom of the pool at Section 1.
   e. The distance from the brink to the intersection of the nappe with the pool under the nappe is calculated. The formula for a free falling object,
      $$y = v0 * t + 0.5 * g * t^2$$
      is used to calculate the time required for the water to fall to the top of the pool. The horizontal distance the water traveled is then calculated using this time. An initial vertical velocity, v0, of 0 and a horizontal velocity equal to the brink velocity, vb, is assumed.
   f. The line from the brink to the intersection of the nappe with the pool is then extended to the bottom of the pool. This defines the location of Section 1.

GRADE CONTROL STRUCTURE - STA 29+00
DROP SPILLWAY

g. The length of the hydraulic jump is calculated using the equation Ljump = 6.9 * (y2 - y1), where y1 is the depth at section 1 and y2 is the conjugate depth at Section 2.

4. The height of the end sill required to contain the hydraulic jump is calculated. That is, the sill is designed so that the depth upstream of the sill is greater than or equal to the conjugate depth at Section 2. The effect of submergence caused by high tailwater is considered if required.

Calculate design for rectangular straight drop spillway.

Reference: Chow, Ven Te, "Open Channel Hydraulics," McGraw-Hill, 1959. (pp. 423-425).

D =	(Q/B)^2 / g / Drop^3 =	0.93
Ld =	4.30 * D^0.270 * Drop =	21.11
yp =	1.00 * D^0.220 * Drop =	4.93
y1 =	0.54 * D^0.425 * Drop =	2.62
y2 =	1.66 * D^0.270 * Drop =	8.15

Calculate brink conditions at the top of the drop:

Reference: Blevins, Robert D. "Applied Fluid Dynamics Handbook," Van Nostrand Reinhold, 1984. (pp. 208-209)

The depth at the brink is a function of the approach channel slope Soa and the channel slope required for critical flow Sc.

T A B L E O F B R I N K F A C T O R S (From Reference)

Soa/Sc	-6.00	-4.00	-2.00	0.00	1.00	2.00	4.00	6.00
db/dc	0.750	0.745	0.730	0.715	0.680	0.650	0.575	0.525

Soa/Sc =	2.25	(approach slope / critical slope)
db/dc =	0.641	(brink factor)
db =	2.87 ft	(brink depth)
vb =	18.43 fps	(brink velocity)

GRADE CONTROL STRUCTURE - STA 29+00
DROP SPILLWAY

Calculate design for a trapaziodal drop spillway with lined floor:

Reference: Agostini, R., A. Bizzarri & M. Masetti, "Flexible Structures in River and Stream Training Works," S.P.A. Officine Maccaferri, Bologna, 1981. (pp. 34-37 and 52-54)

	y (ft)	v (fps)	hv (ft)	A (sq ft)	T (ft)	Fr	EG (ft)
Approach	3.55	14.42	3.23	153.01	50.20	1.46	58.34
Section 1	2.20	24.83	9.58	88.84	44.80	3.11	58.34
Section 2	7.83	5.46	0.46	404.32	67.31	0.39	54.78

Conjugate depth calculations at Section 2 are based on hydraulic depth. (Reference: Blevins, Robert D., "Applied Fluid Dynamics Handbook," Van Nostrand Reinhold, 1984. p.196)

alpha = 1.28 (working variable for equation)
beta = 0.90 (working variable for equation)

Conjugate depth equation
0.000 (= 0 when correct sequent depth is obtained)

db/2 elev = 52.99 ft (water centroid elev at brink)
yp elev = 51.49 ft (elev of pool at bottom of drop)
Fall_p = 1.51 ft (vertical fall - centroid to yp)
Fall_1 = 6.43 ft (vertical fall - centroid to floor)

L_p = 5.64 ft (horiz distance - brink to yp)
L_1 = 24.06 ft (horiz distance - brink to y1)
L_2 = 38.83 ft (horiz dist - y1 to y2, jump length

As a check, calculate weir equation coefficient for design

Weir formula: $Q = C * B * H^{1.5}$

H = 6.78 ft (head on weir, H = ya + hva)
C = 3.47 (equiv weir coeff, C = Q / L / H^1.5)
yc/H = 0.660 ==> OK, (should = approx 2/3)

GRADE CONTROL STRUCTURE - STA 29+00
DROP SPILLWAY

Calculate height of sill required at end of stilling basin:
(Note: A rectangular channel is assumed for sill calculations.)

Reference: Blevins, Robert D. "Applied Fluid Dynamics Handbook," Van Nostrand Reinhold, 1984. (pp. 201-206)]

Sill formula:

$$Qsill = (2/3)^{1.5} * Csill * Bsill * g^{0.5} * (ha + Va/2/g)^{1.5}$$

where:

Csill = 0.848*F
F = function of ha/Lsill and ha/(ha+hb)

The formula is solved by trial and error for Q.

y2 =	7.83	ft	(sequent depth at Section 2)
Bsill =	36.00	ft	(width of rectangular channel)
hbmin =	2.24		(min sill height req'd, ha+hb = y2)
hb =	2.25	ft	(sill height)
ha =	5.60	ft	(height of water above top of sill)
ha+hb =	7.85	ft	==> OK, (ha+hb > y2, jump contained
Lsill =	2.00	ft	
ha/Lsill =	2.80		
ha/(ha+hb) =	0.71		
F =	1.40		(WARNING: Extrapolated Value)
Csill =	1.19		
Vsill =	7.81	fps	(assuming a rectangular channel)
hvsill =	0.95	ft	(assuming a rectangular channel)
Qsill =	2206	cfs	

Equivalent sill weir coefficient C = 3.66

Check for submergence of sill -
Tailwater conditions: From HEC-2 SECNO 2800

y3 =	5.02	ft	(tailwater depth)
hc =	2.77	ft	(height of tailwater above sill)
hc/ha =	0.49		==> OK, (hc/ha < 0.80)
Qdrown =	1.000		(sill not submerged)
Qadj =	2206	cfs	(sill not submerged, Qadj = Qsill)

THE FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

DROP INLET HYDRAULICS - STA. 41+75

DIBBLE AND ASSOCIATES CONSULTING ENGINEERS

White Tanks #4 FRS Channel - Sta 41+75
CHANNEL HYDRAULICS CHARACTERISTICS

Rectangular Channel

```
**            T                 **
 **----------------------------**
  **          2.86          **
Za **       FT DEEP      ** Zb
    **                  **
     ******************
              B
```

Q =	2206.0	cfs
So =	0.0047	ft/ft
n =	0.015	
B =	60	ft
Za =	0 : 1	
Zb =	0 : 1	
Zave =	0.00 : 1	
g =	32.175	ft/sec^2

TRIAL DEPTH = 2.8568574 ft

NORMAL FLOW CALCULATIONS:

flow (Qn) =	2206.0	cfs
depth (dn) =	2.86	ft
velocity (Vn) =	12.87	fps
Froude # (Fn) =	1.342	

CRITICAL FLOW CALCULATIONS:

depth (dc) =	3.476	ft
velocity (Vc) =	10.58	fps
slope (Sc) =	0.002505	ft/ft

Vc^2/g-Ac/Tc = -0.00000
(Equals 0 at Critical Depth)

For normal depth calcs:

An =	171.411	sq ft
Pn =	65.714	ft
Rn =	2.608	ft
Tn =	60.000	ft

For critical depth calcs:

Ac =	208.584	sq ft
Pc =	66.953	ft
Rc =	3.115	ft
Tc =	60.000	ft

SEQUENT DEPTH CALCULATIONS:

ds =	4.179857	
As =	250.791	sq ft
Ps =	68.360	ft
Rs =	3.669	ft
Ts =	60.000	ft
Vs =	8.796	fps
Froude # (Fs) =	0.758	

(Formulas for hydraulic jumps in trapazoidal channels are from FHWA's "Hydraulic Design of Energy Dissipators for Culverts and Channels, HEC No. 14, p.VI-8)

ds_t =	NA
t = B/z/dn =	NA
J = ds_t/dn =	NA
Fn - Fjump =	NA (= 0)

(Equals 0 at sequent depth)

GRADE CONTROL STRUCTURE - STA 41+75
DROP SPILLWAY

Given:

Q =	2206 cfs	
n =	0.015	(Manning's n factor)
g =	32.175 ft/sec/sec	(gravitational constant)

Drop approach conditions: From HEC-2 SECNO 4190

ya =	2.40 ft	(depth of flow)
va =	15.32 fps	(velocity)
hva =	3.65 ft	(velocity head)
Soa =	0.0047 ft/ft	(channel slope)

D R O P G E O M E T R Y

	Sta	Elev	B	Za	Zb	Zave
Section 0	41+75	62.35	60.00	0.00	0.00	0.00
Section 1	41+63	58.35	60.00	1.50	1.50	1.50
Section 2	41+25	58.29	60.00	2.00	2.00	2.00

Drop Width = 60.00
Drop Height = 4.00

Calculate critial flow parameters for Section 0:

Solution is by trail and error.

yc =	3.476 ft	(critical depth)
Sc =	0.0025 ft/ft	(critical slope)
Vc =	10.58 fps	(critical velocity)
Ac =	208.58 sq ft	(cross sectional area of flow)
Pc =	66.95 ft	(wetted perimeter)
Rc =	3.12 ft	(hydraulic radius)
Tc =	60.00 ft	(top of water surface width)

Vc^2/g-Ac/Tc =-0.000 (= 0 at correct Critical Depth)

GRADE CONTROL STRUCTURE - STA 41+75
DROP SPILLWAY

Method used for trapaziodal drop spillway design.

Note: The references used are noted in the appropriate locations in the calculations that follow.

The following steps are used in the analysis:

1. The parameters for a straight rectangular drop spillway are calculated.

2. Brink conditions are calculated at the top of the drop.

3. The trapeziodal drop spillway design is as follows.

   a. These calculations assume a free falling nappe. Therefore, the drop height must be greater than or equal to the depth of the pool, yp, at the bottom of the drop. Use the value of yp calculated above for a rectangular straight drop spillway.
   b. Energy is balanced between the Approach Section and Section 1 at the bottom of the drop assuming no energy loss in the drop. That is, the energy grade elevation at the Approach Section and Section 1 are equal. The solution is by trial and error.
   c. Hydraulic jump equations are used to solve for the conjugate depth at Section 2. The solution is by trial and error.
   d. A straight line is assumed between the centroid of the water on the brink, the intersection of the nappe with the pool under the nappe and the bottom of the pool at Section 1.
   e. The distance from the brink to the intersection of the nappe with the pool under the nappe is calculated. The formula for a free falling object,

      $$y = v0 * t + 0.5 * g * t^2$$

      is used to calculate the time required for the water to fall to the top of the pool. The horizontal distance the water traveled is then calculated using this time. An initial vertical velocity, v0, of 0 and a horizontal velocity equal to the brink velocity, vb, is assumed.
   f. The line from the brink to the intersection of the nappe with the pool is then extended to the bottom of the pool. This defines the location of Section 1.

GRADE CONTROL STRUCTURE - STA 41+75
DROP SPILLWAY

g. The length of the hydraulic jump is calculated using the equation Ljump = 6.9 * (y2 - y1), where y1 is the depth at section 1 and y2 is the conjugate depth at Section 2.

4. The height of the end sill required to contain the hydraulic jump is calculated. That is, the sill is designed so that the depth upstream of the sill is greater than or equal to the conjugate depth at Section 2. The effect of submergence caused by high tailwater is considered if required.

Calculate design for rectangular straight drop spillway.

Reference: Chow, Ven Te, "Open Channel Hydraulics," McGraw-Hill, 1959. (pp. 423-425).

D =	(Q/B)^2 / g / Drop^3 =	0.66
Ld =	4.30 * D^0.270 * Drop =	15.35
yp =	1.00 * D^0.220 * Drop =	3.65
y1 =	0.54 * D^0.425 * Drop =	1.81
y2 =	1.66 * D^0.270 * Drop =	5.93

Calculate brink conditions at the top of the drop:

Reference: Blevins, Robert D. "Applied Fluid Dynamics Handbook," Van Nostrand Reinhold, 1984. (pp. 208-209)

The depth at the brink is a function of the approach channel slope Soa and the channel slope required for critical flow Sc.

T A B L E O F B R I N K F A C T O R S (From Reference)

Soa/Sc	-6.00	-4.00	-2.00	0.00	1.00	2.00	4.00	6.00
db/dc	0.750	0.745	0.730	0.715	0.680	0.650	0.575	0.525

Soa/Sc =	1.88	(approach slope / critical slope)
db/dc =	0.654	(brink factor)
db =	2.27 ft	(brink depth)
vb =	16.18 fps	(brink velocity)

GRADE CONTROL STRUCTURE - STA 41+75
DROP SPILLWAY

Calculate design for a trapaziodal drop spillway with lined floor:

Reference: Agostini, R., A. Bizzarri & M. Masetti, "Flexible Structures in River and Stream Training Works," S.P.A. Officine Maccaferri, Bologna, 1981. (pp. 34-37 and 52-54)

	y (ft)	v (fps)	hv (ft)	A (sq ft)	T (ft)	Fr	EG (ft)
Approach	2.40	15.32	3.65	144.00	60.00	1.74	68.40
Section 1	1.51	23.44	8.54	94.13	64.54	3.42	68.40
Section 2	6.34	4.79	0.36	460.93	85.37	0.36	64.99

Conjugate depth calculations at Section 2 are based on hydraulic depth. (Reference: Blevins, Robert D., "Applied Fluid Dynamics Handbook," Van Nostrand Reinhold, 1984. p.196)

alpha = 1.12 (working variable for equation)
beta = 0.96 (working variable for equation)

Conjugate depth equation
0.000 (= 0 when correct sequent depth is obtained)

db/2 elev =	63.49 ft	(water centroid elev at brink)
yp elev =	62.00 ft	(elev of pool at bottom of drop)
Fall_p =	1.49 ft	(vertical fall - centroid to yp)
Fall_1 =	5.14 ft	(vertical fall - centroid to floor)
L_p =	4.92 ft	(horiz distance - brink to yp)
L_1 =	16.97 ft	(horiz distance - brink to y1)
L_2 =	33.33 ft	(horiz dist - y1 to y2, jump length

As a check, calculate weir equation coefficient for design

Weir formula: $Q = C * B * H^{1.5}$

H =	6.05 ft	(head on weir, H = ya + hva)
C =	2.47	(equiv weir coeff, C = Q / L / H^1.5)
yc/H =	0.575	==> OK, (should = approx 2/3)

GRADE CONTROL STRUCTURE - STA 41+75
DROP SPILLWAY

Calculate height of sill required at end of stilling basin:
(Note: A rectangular channel is assumed for sill calculations.)

Reference: Blevins, Robert D. "Applied Fluid Dynamics Handbook," Van Nostrand Reinhold, 1984. (pp. 201-206)]

Sill formula:

$$Qsill = (2/3)^{1.5} * Csill * Bsill * g^{0.5} * (ha + Va/2/g)^{1.5}$$

where:

Csill = 0.848*F
F = function of ha/Lsill and ha/(ha+hb)

The formula is solved by trial and error for Q.

y2 =	6.34	ft	(sequent depth at Section 2)
Bsill =	60.00	ft	(width of rectangular channel)
hbmin =	1.71		(min sill height req'd, ha+hb = y2)
hb =	1.75	ft	(sill height)
ha =	4.61	ft	(height of water above top of sill)
ha+hb =	6.36	ft	==> OK, (ha+hb > y2, jump contained
Lsill =	2.00	ft	
ha/Lsill =	2.31		
ha/(ha+hb) =	0.72		
F =	1.34		(WARNING: Extrapolated Value)
Csill =	1.14		
Vsill =	5.78	fps	(assuming a rectangular channel)
hvsill =	0.52	ft	(assuming a rectangular channel)
Qsill =	2450	cfs	

Equivalent sill weir coefficient C = 3.51

Check for submergence of sill -
Tailwater conditions: From HEC-2 SECNO 4100

y3 =	5.96	ft	(tailwater depth)
hc =	4.21	ft	(height of tailwater above sill)
hc/ha =	0.91		(hc/ha > 0.80, sill submerged)
Qdrown =	0.900		(drowned weir performance ratio)
Qadj =	2206	cfs	(drowned capacity = Qdrown * Qsill)

THE FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

DROP INLET HYDRAULICS - STA. 51+80

DIBBLE AND ASSOCIATES CONSULTING ENGINEERS

White Tanks #4 FRS Channel - Sta 51+80
CHANNEL HYDRAULICS CHARACTERISTICS

Trapizoidal Channel

```
**            T              **
 **-------------------------**
  **         2.73         **
Za **      FT DEEP      ** Zb
    **                **
     ******************
              B
```

Q =	2206.0	cfs
So =	0.007	ft/ft
n =	0.015	
B =	51	ft
Za =	0	: 1
Zb =	2	: 1
Zave =	1.00	: 1
g =	32.175	ft/sec^2

TRIAL DEPTH = 2.7266961 ft

NORMAL FLOW CALCULATIONS:

flow (Qn) =	2206.0	cfs
depth (dn) =	2.73	ft
velocity (Vn) =	15.06	fps
Froude # (Fn) =	1.648	

CRITICAL FLOW CALCULATIONS:

depth (dc) =	3.777	ft
velocity (Vc) =	10.66	fps
slope (Sc) =	0.002384	ft/ft

Vc^2/g-Ac/Tc = -0.00000
(Equals 0 at Critical Depth)

For normal depth calcs:

An =	146.496	sq ft
Pn =	59.824	ft
Rn =	2.449	ft
Tn =	56.453	ft

For critical depth calcs:

Ac =	206.895	sq ft
Pc =	63.223	ft
Rc =	3.272	ft
Tc =	58.554	ft

SEQUENT DEPTH CALCULATIONS:

ds =	5.057115	
As =	283.487	sq ft
Ps =	67.365	ft
Rs =	4.208	ft
Ts =	61.114	ft
Vs =	7.782	fps
Froude # (Fs) =	0.637	

(Formulas for hydraulic jumps in trapazoidal channels are from FHWA's "Hydraulic Design of Energy Dissipators for Culverts and Channels, HEC No. 14, p.VI-8)

ds_t =	5.0571155	
t = B/z/dn =	18.704	
J = ds_t/dn =	1.855	
Fn - Fjump =	0.000	(= 0)

(Equals 0 at sequent depth)

GRADE CONTROL STRUCTURE - STA 51+80
DROP SPILLWAY

Given:

Q =	2206 cfs	
n =	0.015	(Manning's n factor)
g =	32.175 ft/sec/sec	(gravitational constant)

Drop approach conditions: From HEC-2 SECNO 5200

ya =	2.70 ft	(depth of flow)
va =	15.21 fps	(velocity)
hva =	3.60 ft	(velocity head)
Soa =	0.0070 ft/ft	(channel slope)

D R O P G E O M E T R Y

	Sta	Elev	B	Za	Zb	Zave
Section 0	51+80	71.56	51.00	0.00	2.00	1.00
Section 1	51+70	68.06	51.00	0.00	2.00	1.00
Section 2	51+29	68.01	51.00	0.00	2.00	1.00

Drop Width = 51.00
Drop Height = 3.50

Calculate critial flow parameters for Section 0:

Solution is by trail and error.

yc =	3.777 ft	(critical depth)
Sc =	0.0024 ft/ft	(critical slope)
Vc =	10.66 fps	(critical velocity)
Ac =	206.89 sq ft	(cross sectional area of flow)
Pc =	63.22 ft	(wetted perimeter)
Rc =	3.27 ft	(hydraulic radius)
Tc =	58.55 ft	(top of water surface width)

Vc^2/g-Ac/Tc = 0.000 (= 0 at correct Critical Depth)

GRADE CONTROL STRUCTURE - STA 51+80
DROP SPILLWAY

Method used for trapaziodal drop spillway design.

Note: The references used are noted in the appropriate locations in the calculations that follow.

The following steps are used in the analysis:

1. The parameters for a straight rectangular drop spillway are calculated.

2. Brink conditions are calculated at the top of the drop.

3. The trapeziodal drop spillway design is as follows.

   a. These calculations assume a free falling nappe. Therefore, the drop height must be greater than or equal to the depth of the pool, yp, at the bottom of the drop. Use the value of yp calculated above for a rectangular straight drop spillway.
   b. Energy is balanced between the Approach Section and Section 1 at the bottom of the drop assuming no energy loss in the drop. That is, the energy grade elevation at the Approach Section and Section 1 are equal. The solution is by trial and error.
   c. Hydraulic jump equations are used to solve for the conjugate depth at Section 2. The solution is by trial and error.
   d. A straight line is assumed between the centroid of the water on the brink, the intersection of the nappe with the pool under the nappe and the bottom of the pool at Section 1.
   e. The distance from the brink to the intersection of the nappe with the pool under the nappe is calculated. The formula for a free falling object,
      $$y = v0 * t + 0.5 * g * t^2$$
      is used to calculate the time required for the water to fall to the top of the pool. The horizontal distance the water traveled is then calculated using this time. An initial vertical velocity, v0, of 0 and a horizontal velocity equal to the brink velocity, vb, is assumed.
   f. The line from the brink to the intersection of the nappe with the pool is then extended to the bottom of the pool. This defines the location of Section 1.

GRADE CONTROL STRUCTURE - STA 51+80
DROP SPILLWAY

g. The length of the hydraulic jump is calculated using the equation Ljump = 6.9 * (y2 - y1), where y1 is the depth at section 1 and y2 is the conjugate depth at Section 2.

4. The height of the end sill required to contain the hydraulic jump is calculated. That is, the sill is designed so that the depth upstream of the sill is greater than or equal to the conjugate depth at Section 2. The effect of submergence caused by high tailwater is considered if required.

Calculate design for rectangular straight drop spillway.

Reference: Chow, Ven Te, "Open Channel Hydraulics," McGraw-Hill, 1959. (pp. 423-425).

D =	(Q/B)^2 / g / Drop^3 =	1.36
Ld =	4.30 * D^0.270 * Drop =	16.34
yp =	1.00 * D^0.220 * Drop =	3.74
y1 =	0.54 * D^0.425 * Drop =	2.15
y2 =	1.66 * D^0.270 * Drop =	6.31

Calculate brink conditions at the top of the drop:

Reference: Blevins, Robert D. "Applied Fluid Dynamics Handbook," Van Nostrand Reinhold, 1984. (pp. 208-209)

The depth at the brink is a function of the approach channel slope Soa and the channel slope required for critical flow Sc.

T A B L E O F B R I N K F A C T O R S (From Reference)

Soa/Sc	-6.00	-4.00	-2.00	0.00	1.00	2.00	4.00	6.00
db/dc	0.750	0.745	0.730	0.715	0.680	0.650	0.575	0.525

Soa/Sc =	2.94	(approach slope / critical slope)
db/dc =	0.615	(brink factor)
db =	2.32 ft	(brink depth)
vb =	17.81 fps	(brink velocity)

GRADE CONTROL STRUCTURE - STA 51+80
DROP SPILLWAY

Calculate design for a trapaziodal drop spillway with lined floor:

Reference: Agostini, R., A. Bizzarri & M. Masetti, "Flexible Structures in River and Stream Training Works," S.P.A. Officine Maccaferri, Bologna, 1981. (pp. 34-37 and 52-54)

	y (ft)	v (fps)	hv (ft)	A (sq ft)	T (ft)	Fr	EG (ft)
Approach	2.70	15.21	3.60	144.99	56.40	1.67	77.86
Section 1	1.85	22.62	7.95	97.52	54.69	2.99	77.86
Section 2	6.93	5.50	0.47	401.18	64.85	0.39	75.41

Conjugate depth calculations at Section 2 are based on hydraulic depth. (Reference: Blevins, Robert D., "Applied Fluid Dynamics Handbook," Van Nostrand Reinhold, 1984. p.196)

alpha = 1.00 (working variable for equation)
beta = 1.00 (working variable for equation)

Conjugate depth equation
0.000 (= 0 when correct sequent depth is obtained)

db/2 elev =	72.72 ft	(water centroid elev at brink)
yp elev =	71.80 ft	(elev of pool at bottom of drop)
Fall_p =	0.92 ft	(vertical fall - centroid to yp)
Fall_1 =	4.66 ft	(vertical fall - centroid to floor)
L_p =	4.26 ft	(horiz distance - brink to yp)
L_1 =	21.60 ft	(horiz distance - brink to y1)
L_2 =	35.05 ft	(horiz dist - y1 to y2, jump length

As a check, calculate weir equation coefficient for design

Weir formula: $Q = C * B * H^{1.5}$

H =	6.30 ft	(head on weir, H = ya + hva)
C =	2.74	(equiv weir coeff, C = Q / L / H^1.5)
yc/H =	0.600	==> OK, (should = approx 2/3)

GRADE CONTROL STRUCTURE - STA 51+80
DROP SPILLWAY

Calculate height of sill required at end of stilling basin:
(Note: A rectangular channel is assumed for sill calculations.)

Reference: Blevins, Robert D. "Applied Fluid Dynamics Handbook," Van Nostrand Reinhold, 1984. (pp. 201-206)]

Sill formula:

$$Qsill = (2/3)^{1.5} * Csill * Bsill * g^{0.5} * (ha + Va/2/g)^{1.5}$$

where:

Csill = 0.848*F
F = function of ha/Lsill and ha/(ha+hb)

The formula is solved by trial and error for Q.

y2 =	6.93	ft	(sequent depth at Section 2)
Bsill =	51.00	ft	(width of rectangular channel)
hbmin =	2.23		(min sill height req'd, ha+hb = y2)
hb =	2.25	ft	(sill height)
ha =	4.70	ft	(height of water above top of sill)
ha+hb =	6.95	ft	==> OK, (ha+hb > y2, jump contained
Lsill =	2.00	ft	
ha/Lsill =	2.35		
ha/(ha+hb) =	0.68		
F =	1.35		(WARNING: Extrapolated Value)
Csill =	1.15		
Vsill =	6.22	fps	(assuming a rectangular channel)
hvsill =	0.60	ft	(assuming a rectangular channel)
Qsill =	2206	cfs	

Equivalent sill weir coefficient C = 3.54

Check for submergence of sill -
Tailwater conditions: From HEC-2 SECNO 5100

y3 =	4.20	ft	(tailwater depth)
hc =	1.95	ft	(height of tailwater above sill)
hc/ha =	0.41		==> OK, (hc/ha < 0.80)
Qdrown =	1.000		(sill not submerged)
Qadj =	2206	cfs	(sill not submerged, Qadj = Qsill)

THE FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

DROP INLET HYDRAULICS - STA. 59+00

DIBBLE AND ASSOCIATES CONSULTING ENGINEERS

White Tanks #4 FRS Channel - Sta 59+00
CHANNEL HYDRAULICS CHARACTERISTICS

Trapizoidal Channel

```
**            T              **
 **-------------------------**
  **         3.55         **
Za **      FT DEEP      ** Zb
    **                 **
     ******************
              B
```

Q =	2206.0	cfs
So =	0.005	ft/ft
n =	0.015	
B =	36	ft
Za =	2 : 1	
Zb =	2 : 1	
Zave =	2.00 : 1	
g =	32.175	ft/sec^2

TRIAL DEPTH = 3.5515454 ft

NORMAL FLOW CALCULATIONS:

flow (Qn) =	2206.0	cfs
depth (dn) =	3.55	ft
velocity (Vn) =	14.41	fps
Froude # (Fn) =	1.455	

CRITICAL FLOW CALCULATIONS:

depth (dc) =	4.477	ft
velocity (Vc) =	10.96	fps
slope (Sc) =	0.002224	ft/ft

Vc^2/g-Ac/Tc = 0.00000
(Equals 0 at Critical Depth)

For normal depth calcs:

An =	153.083	sq ft
Pn =	51.883	ft
Rn =	2.951	ft
Tn =	50.206	ft

For critical depth calcs:

Ac =	201.273	sq ft
Pc =	56.023	ft
Rc =	3.593	ft
Tc =	53.909	ft

SEQUENT DEPTH CALCULATIONS:

ds =	5.534	
As =	260.484	sq ft
Ps =	60.750	ft
Rs =	4.288	ft
Ts =	58.137	ft
Vs =	8.469	fps
Froude # (Fs) =	0.705	

(Formulas for hydraulic jumps in trapazoidal channels are from FHWA's "Hydraulic Design of Energy Dissipators for Culverts and Channels, HEC No. 14, p.VI-8)

ds_t =	5.534
t = B/z/dn =	5.068
J = ds_t/dn =	1.558
Fn - Fjump =	0.000 (= 0)

(Equals 0 at sequent depth)

GRADE CONTROL STRUCTURE - STA 59+00
DROP SPILLWAY

Given:

Q =	2206 cfs	
n =	0.015	(Manning's n factor)
g =	32.175 ft/sec/sec	(gravitational constant)

Drop approach conditions: From HEC-2 SECNO 5950

ya =	3.49 ft	(depth of flow)
va =	14.71 fps	(velocity)
hva =	3.36 ft	(velocity head)
Soa =	0.0050 ft/ft	(channel slope)

D R O P G E O M E T R Y

	Sta	Elev	B	Za	Zb	Zave
Section 0	59+00	78.78	36.00	2.00	2.00	2.00
Section 1	58+85	73.79	36.00	2.00	2.00	2.00
Section 2	58+37	73.73	36.00	2.00	2.00	2.00

Drop Width = 36.00
Drop Height = 4.99

Calculate critial flow parameters for Section 0:

Solution is by trail and error.

yc =	4.477 ft	(critical depth)
Sc =	0.0022 ft/ft	(critical slope)
Vc =	10.96 fps	(critical velocity)
Ac =	201.27 sq ft	(cross sectional area of flow)
Pc =	56.02 ft	(wetted perimeter)
Rc =	3.59 ft	(hydraulic radius)
Tc =	53.91 ft	(top of water surface width)

Vc^2/g-Ac/Tc =-0.000 (= 0 at correct Critical Depth)

GRADE CONTROL STRUCTURE - STA 59+00
DROP SPILLWAY

Method used for trapaziodal drop spillway design.

Note: The references used are noted in the appropriate locations in the calculations that follow.

The following steps are used in the analysis:

1. The parameters for a straight rectangular drop spillway are calculated.

2. Brink conditions are calculated at the top of the drop.

3. The trapeziodal drop spillway design is as follows.

   a. These calculations assume a free falling nappe. Therefore, the drop height must be greater than or equal to the depth of the pool, yp, at the bottom of the drop. Use the value of yp calculated above for a rectangular straight drop spillway.
   b. Energy is balanced between the Approach Section and Section 1 at the bottom of the drop assuming no energy loss in the drop. That is, the energy grade elevation at the Approach Section and Section 1 are equal. The solution is by trial and error.
   c. Hydraulic jump equations are used to solve for the conjugate depth at Section 2. The solution is by trial and error.
   d. A straight line is assumed between the centroid of the water on the brink, the intersection of the nappe with the pool under the nappe and the bottom of the pool at Section 1.
   e. The distance from the brink to the intersection of the nappe with the pool under the nappe is calculated. The formula for a free falling object,
      $$y = v0 * t + 0.5 * g * t^2$$
      is used to calculate the time required for the water to fall to the top of the pool. The horizontal distance the water traveled is then calculated using this time. An initial vertical velocity, v0, of 0 and a horizontal velocity equal to the brink velocity, vb, is assumed.
   f. The line from the brink to the intersection of the nappe with the pool is then extended to the bottom of the pool. This defines the location of Section 1.

GRADE CONTROL STRUCTURE - STA 59+00
DROP SPILLWAY

g. The length of the hydraulic jump is calculated using the equation Ljump = 6.9 * (y2 - y1), where y1 is the depth at section 1 and y2 is the conjugate depth at Section 2.

4. The height of the end sill required to contain the hydraulic jump is calculated. That is, the sill is designed so that the depth upstream of the sill is greater than or equal to the conjugate depth at Section 2. The effect of submergence caused by high tailwater is considered if required.

Calculate design for rectangular straight drop spillway.

Reference: Chow, Ven Te, "Open Channel Hydraulics," McGraw-Hill, 1959. (pp. 423-425).

D =	(Q/B)^2 / g / Drop^3 =	0.94
Ld =	4.30 * D^0.270 * Drop =	21.10
yp =	1.00 * D^0.220 * Drop =	4.92
y1 =	0.54 * D^0.425 * Drop =	2.62
y2 =	1.66 * D^0.270 * Drop =	8.14

Calculate brink conditions at the top of the drop:

Reference: Blevins, Robert D. "Applied Fluid Dynamics Handbook," Van Nostrand Reinhold, 1984. (pp. 208-209)

The depth at the brink is a function of the approach channel slope Soa and the channel slope required for critical flow Sc.

T A B L E O F B R I N K F A C T O R S (From Reference)

Soa/Sc	-6.00	-4.00	-2.00	0.00	1.00	2.00	4.00	6.00
db/dc	0.750	0.745	0.730	0.715	0.680	0.650	0.575	0.525

Soa/Sc =	2.25	(approach slope / critical slope)
db/dc =	0.641	(brink factor)
db =	2.87 ft	(brink depth)
vb =	18.43 fps	(brink velocity)

GRADE CONTROL STRUCTURE - STA 59+00
DROP SPILLWAY

Calculate design for a trapaziodal drop spillway with lined floor:

Reference: Agostini, R., A. Bizzarri & M. Masetti, "Flexible Structures in River and Stream Training Works," S.P.A. Officine Maccaferri, Bologna, 1981. (pp. 34-37 and 52-54)

	y (ft)	v (fps)	hv (ft)	A (sq ft)	T (ft)	Fr	EG (ft)
Approach	3.49	14.71	3.36	150.00	49.96	1.50	85.63
Section 1	2.19	24.92	9.65	88.53	44.77	3.12	85.63
Section 2	7.84	5.44	0.46	405.37	67.37	0.39	82.03

Conjugate depth calculations at Section 2 are based on hydraulic depth. (Reference: Blevins, Robert D., "Applied Fluid Dynamics Handbook," Van Nostrand Reinhold, 1984. p.196)

alpha = 1.28 (working variable for equation)
beta = 0.90 (working variable for equation)

Conjugate depth equation
0.000 (= 0 when correct sequent depth is obtained)

db/2 elev =	80.21 ft	(water centroid elev at brink)
yp elev =	78.71 ft	(elev of pool at bottom of drop)
Fall_p =	1.50 ft	(vertical fall - centroid to yp)
Fall_1 =	6.42 ft	(vertical fall - centroid to floor)
L_p =	5.63 ft	(horiz distance - brink to yp)
L_1 =	24.07 ft	(horiz distance - brink to y1)
L_2 =	38.99 ft	(horiz dist - y1 to y2, jump length

As a check, calculate weir equation coefficient for design

Weir formula: $Q = C * B * H^{1.5}$

H =	6.85 ft	(head on weir, H = ya + hva)
C =	3.42	(equiv weir coeff, C = Q / L / H^1.5)
yc/H =	0.654	==> OK, (should = approx 2/3)

GRADE CONTROL STRUCTURE - STA 59+00
DROP SPILLWAY

Calculate height of sill required at end of stilling basin:
(Note: A rectangular channel is assumed for sill calculations.)

Reference: Blevins, Robert D. "Applied Fluid Dynamics Handbook," Van Nostrand Reinhold, 1984. (pp. 201-206)]

Sill formula:

$$Qsill = (2/3)^{1.5} * Csill * Bsill * g^{0.5} * (ha + Va/2/g)^{1.5}$$

where:

Csill = 0.848*F
F = function of ha/Lsill and ha/(ha+hb)

The formula is solved by trial and error for Q.

y2 =	7.84	ft	(sequent depth at Section 2)
Bsill =	36.00	ft	(width of rectangular channel)
hbmin =	2.25		(min sill height req'd, ha+hb = y2)
hb =	2.25	ft	(sill height)
ha =	5.60	ft	(height of water above top of sill)
ha+hb =	7.85	ft	==> OK, (ha+hb > y2, jump contained
Lsill =	2.00	ft	
ha/Lsill =	2.80		
ha/(ha+hb) =	0.71		
F =	1.40		(WARNING: Extrapolated Value)
Csill =	1.19		
Vsill =	7.81	fps	(assuming a rectangular channel)
hvsill =	0.95	ft	(assuming a rectangular channel)
Qsill =	2206	cfs	

Equivalent sill weir coefficient C = 3.66

Check for submergence of sill -
Tailwater conditions: From HEC-2 SECNO 5800

y3 =	5.00	ft	(tailwater depth)
hc =	2.75	ft	(height of tailwater above sill)
hc/ha =	0.49		==> OK, (hc/ha < 0.80)
Qdrown =	1.000		(sill not submerged)
Qadj =	2206	cfs	(sill not submerged, Qadj = Qsill)

THE FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

DROP INLET HYDRAULICS - REFERENCES

DIBBLE AND ASSOCIATES CONSULTING ENGINEERS

OPEN-CHANNEL HYDRAULICS

VEN TE CHOW, Ph.D.

Professor of Hydraulic Engineering
University of Illinois

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15-15. The Straight Drop Spillway. The aerated free-falling nappe in a straight drop spillway (Fig. 15-18) will reverse its curvature and turn smoothly into supercritical flow on the apron. Consequently, a hydraulic jump may be formed downstream. Based on his own experimental data

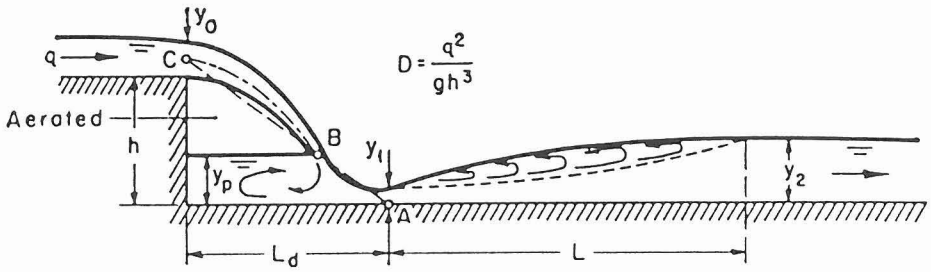


FIG. 15-18. Flow geometry of a straight drop spillway.

and those of Moore [40] and Bakhmeteff and Feodoroff [65], Rand [66] found that the flow geometry at straight drop spillways can be described by functions of the *drop number*, which is defined as

$$D = \frac{q^2}{gh^3} \tag{15-9}$$

where q is the discharge per unit width of the crest of overfall, g is the acceleration of gravity, and h is the height of the drop. The functions are

$$\frac{L_d}{h} = 4.30D^{0.27} \tag{15-10}$$

$$\frac{y_p}{h} = 1.00D^{0.22} \tag{15-11}$$

$$\frac{y_1}{h} = 0.54D^{0.425} \tag{15-12}$$

$$\frac{y_2}{h} = 1.66D^{0.27} \tag{15-13}$$

where L_d is the drop length, that is, the distance from the drop wall to the position of the depth y_1; y_p is the pool depth under the nappe; y_1 is the depth at the toe of the nappe or the beginning of the hydraulic jump; and y_2 is the tailwater depth sequent to y_1. The position of the depth y_1 can be approximately determined by the straight line ABC which joins the point A on the apron at the position of y_1, the point B on the axis of the nappe at the height of pool depth, and the point C on the axis of the nappe at the crest of the fall. The fact that these three points lie on a straight line was also verified by experiment.

For a given height h and discharge q per unit width of the fall crest, the sequent depth y_2 and the drop length L_d can be computed by Eqs. (15-10) and (15-13). On the one hand, if the tailwater depth is less than

y_2, the hydraulic jump will recede downstream. On the other hand, if the tailwater depth is greater than y_2, the jump will be submerged. As the tailwater level rises, the spillway crest may be finally submerged. The spillway will still be effective if the submergence does not reach the control depth on the spillway crest. The upper surface of the submerged nappe may be assumed as a straight line tangent to the upper surface of the free nappe at the point where the nappe plunges into the tailwater. The upper surface of the free nappe may be represented by the general equation given in Art. 14-1.

In the above discussion it is assumed that the length of the spillway crest is the same as the width of the approach channel. If the crest length is less than the width of the approach channel, the contraction at the ends of the spillway notch will be so great that the ends of the nappe may land beyond the stilling-basin sidewalls and the concentration of high velocities at the center of the outlet may cause additional scour in the downstream channel. It is, therefore, important to design the approach end properly by shaping the approach channel to reduce the effect of end contractions.

The straight drop spillway is commonly installed in small drainage structures by the U.S. Soil Conservation Service. The simplest form of such a structure, known as the *box inlet drop spillway*, is simply a rectangular box open at the top and at the downstream end [67–69]. Storm runoff is directed to the box by dikes and headwalls, enters over the upstream end and two sides, and leaves through the open downstream end leading to a channel outlet. A generalized design has also been developed by the Service as a result of tests and analyses at the St. Anthony Falls Hydraulic Laboratory [70,71].

By placing a gridiron or grate on top of the straight drop spillway, the overfalling jet can be separated into a number of long thin sheets of water which fall nearly vertically into the channel below. Thus the energy in the jet can be dissipated without resort to the use of hydraulic jump, and hence wave action can be reduced if $F_1 = 2.5$ to 4.5. This scheme has been adopted by the U.S. Bureau of Reclamation [34,35] for developing a so-called *drop energy dissipator* as a substitute design for USBR basin IV (Art. 15-14). In this design, the grate may be composed of a series of beams, such as steel rails, channel irons, or timbers, which form slots parallel to the direction of flow. The width of the slots is equal to two-thirds the width of the beams. If the rails are tilted downward at an angle of 3° or more, the grate is self-cleaning. On the other hand, if the grate is tilted upward, it can check the upstream water level but may pose a cleaning problem. The length of the grate slots can be computed by

$$L_G = \frac{4.1Q}{WN\sqrt{2gy_1}} \tag{15-14}$$

APPLIED FLUID DYNAMICS HANDBOOK

ROBERT D. BLEVINS

VNR VAN NOSTRAND REINHOLD COMPANY
New York

Table 8-14. Properties of Hydraulic Jumps.

Notation: d_1, d_2 = conjugate depths; $Fr_1 = U_1/(gd_{h1})^{1/2}$ = incoming Froude number based on hydraulic depth d_{h1} [Eq. (8-26)]. See Table 8-2 for definition of geometric parameters. Refs. 8-46 and 8-47.

Section	Equation for Conjugate Depths	$\frac{\text{Energy Dissipated}}{\text{Incoming Energy}} = \frac{E_L}{E_1}$
1. Rectangular	$\left(\frac{d_2}{d_1}\right)^2 - 1 = 2\,Fr_1^2\left(1 - \frac{d_1}{d_2}\right)$ or, equivalently, $\frac{d_2}{d_1} = \frac{1}{2}\left[(1 + 8\,Fr_1^2)^{1/2} - 1\right]$	$\dfrac{2\left(1 - \frac{d_2}{d_1}\right) + Fr_1^2\left[1 - \left(\frac{d_1}{d_2}\right)^2\right]}{2 + Fr_1^2}$ (See alternate forms of this equation in text.)
2. Trapezoidal	$\left(\frac{d_2}{d_1}\right)^2 \alpha\left(\frac{1}{3} + \frac{1}{6}\frac{b}{b + zd_2}\right)$ $- \left(\frac{1}{3} + \frac{1}{6}\frac{b}{b + zd_1}\right) = Fr_1^2\,\beta\left(1 - \frac{1}{\alpha}\frac{d_1}{d_2}\right)$ where $\alpha = \frac{b + zd_2}{b + zd_1}$, $\beta = \frac{b + zd_1}{b + 2zd_1}$	$\dfrac{\frac{2}{\beta}\left(1 - \frac{d_2}{d_1}\right) + Fr_1^2\left[1 - \frac{1}{\alpha}\left(\frac{d_1}{d_2}\right)^2\right]}{\frac{2}{\beta} + Fr_1^2}$ (See adjacent column for α, β.)
3. Triangular	$\left(\frac{d_2}{d_1}\right)^3 - 1 = \frac{3}{2}\,Fr_1^2\left[1 - \left(\frac{d_1}{d_2}\right)^2\right]$	$\dfrac{4\left(1 - \frac{d_2}{d_1}\right) + Fr_1^2\left[1 - \left(\frac{d_1}{d_2}\right)^4\right]}{4 + Fr_1^2}$
4. Circular	Case 1: $d_2/d_o \le 1$: $\beta_2\frac{d_2}{d_1}\frac{m_2}{m_1} - \beta_1 = \dfrac{Fr_1^2\left(1 - \frac{m_1}{m_2}\right)m_1}{2\left(\frac{d_1}{d_o}\right)^2\left(\frac{d_o}{d_1} - 1\right)^{1/2}}$ where $\beta = 1 - \frac{1}{2}\frac{d_o}{d} + \dfrac{2\left(1 - \frac{d}{d_o}\right)^{3/2}\left(\frac{d}{d_o}\right)^{1/2}}{3m}$ $m = A/d_o^2 = (\theta - \sin\theta)/8$ and $d/d_o = \sin^2(\theta/4)$ m and β take on subscript 1 or 2 corresponding to $d = d_1$ or $d = d_2$. - Case 2: $d_2 > d_o$: Downstream pipe is full. d_2 characterizes hydrostatic pressure in downstream pipe. $m_2 = \pi/4$. $\beta_2 = 1 - d_o/(2d_2)$. m_1 and β_1 are defined above.	$\dfrac{2\gamma\left(1 - \frac{d_2}{d_1}\right) + Fr_1^2\left[1 - \left(\frac{m_1}{m_2}\right)^2\right]}{2\gamma + Fr_1^2}$ m is defined in adjacent column. $\gamma = \frac{\sin(\theta_1/2)}{m_1}$
5. Parabola	$\left(\frac{d_2}{d_1}\right)^{5/2} - 1 = \frac{5}{3}\,Fr_1^2\left[1 - \left(\frac{d_1}{d_2}\right)^{3/2}\right]$	$\dfrac{3\left(1 - \frac{d_2}{d_1}\right) + Fr_1^2\left[1 - \left(\frac{d_1}{d_2}\right)^3\right]}{3 + Fr_1^2}$

approach flow. A weir is substantially or completely submerged by the flow it controls. The fluid spills over the weir in a descending stream called the nappe. In contrast, a dam ordinarily controls the flow by means of adjustable spillways or sluice gates.

The most common weirs are either thin-plate weirs, whose purpose is primarily to measure flow, or long-base weirs, whose purpose can be both to raise the fluid level and to measure the flow rate. The sharp-edged thin-plate weir has a sharpened upstream facing edge in a plate (see Table 8-16) so that the water springs from the crest of the weir and falls freely in a sheet, i.e., the nappe. In a long-base rectangular weir, the crest of the weir is horizontal, or nearly so, so that the fluid flows horizontal to the crest for a short distance. There are many intermediate forms of long-base weirs, such as the triangle-shaped Crump weir. Two excellent reviews of weir design and analysis can be found in Refs. 8-7 and 8-58.

If the downstream fluid level is sufficiently low, the flow velocity will become supercritical as the fluid flows over the downward facing side of the weir. Downstream influences cannot propagate up through this supercritical flow to influence the weir flow (see Section 8.2.3). As a result, the volume flow rate over the weir is ordinarily only a function of the upstream approaching flow and the weir geometry. Formulas for flow rate over a two-dimensional weir in a rectangular channel are given in Table 8-16 for various weir designs.

The depth of the upstream flow h_1 must be measured far enough upstream of the weir face so as not to be unduly influenced by the weir geometry. The recommended minimum upstream distance is 2 to 4 times $h_1 + U_1^2/(2g)$ (Ref. 8-7, p. 213).

For thin-plate weirs, the discharge can be computed directly from a single measurement of the upstream depth, and these weirs are primarily used for volume flow rate measurement. The proportional weir is a special form of the thin-plate weir which has a contoured notch to achieve a special form of the depth-discharge relationship. For example, the volume flow rate increases linearly with depth with the Sutro proportional weir (frame 4 of Table 8-16):

$$Q \propto (\beta + h_1). \tag{8-50}$$

This linearity makes the Sutro weir well suited to automated monitoring and control systems. A wide variety of proportional weir designs are available to suit various discharge laws (Refs. 8-7, 8-64, 8-68 through 8-75).

The performance of thin-plate weirs is dependent on the shape of the nappe, which in turn is influenced by the pressures above and below the nappe. The formulas of Table 8-16 apply only for equal pressures on both sides of the nappe. For notched weirs, the free circulation of air about the nappe will equalize the pressures. For the full-length, rectangular thin-plate weir (frame 1 of Table 8-16), a vent must be provided to convey air to the underside of the nappe to equalize pressures and replace the air drawn into the nappe (Refs. 8-1, p. 363; 8-7, p. 78).

The volume flow rate (discharge) Q over a long-based weir is somewhat more difficult to compute than that for a thin plate weir, since the approach depth and velocity appear on the right-hand side of the discharge equation. As a result, the volume flow rate over a long-base weir must be found by trial and error using the identity $Q = U_1 b(h_1 + h_2)$ with the formulas of Table 8-16. Since the term $h_1 + (U_1^2/2g)$ is nearly equal to h_1, the trial and error solution can be started at $h_1 + (U_1^2/2g) \approx h_1$. The trial and error solution results in a Q versus h_1 calibration curve which is fixed by the weir geometry.

Three-dimensional long-base and compound weirs direct the flow toward the center of the channel. These weirs can achieve greater accuracy in the measurement of flows at low flows where a given error in h_1 can produce a large error in the computed volume flow rate (see Ref. 8-7).

Drowned Weir Performance. At high downstream fluid levels, the flow passing over a weir will remain subcritical and the weir is said to be drowned or submerged. The volume rate of flow over a drowned weir is a function of the ratio of the downstream to upstream fluid levels, h_3/h_1. h_1 and h_3 are the depths of the approach flow and trailing flow above the weir crest, respectively. (See Table 8-16, frame 5 for h_1 and h_3; h_3 may be negative at low flow rates, but it will be positive for a drowned weir.) A drowned weir has a volume flow rate below that predicted with the upstream depth using the conventional formulas of Table 8-16, as shown in Fig. 8-13.

The upper limiting value of h_3/h_1 for which the volume discharge is substantially independent of the downstream fluid level is called the modular limit or the submergence limit (Refs. 8-7, 8-58). For the rectangular broad-base weir (frame 6 of Table 8-16), submergence limits have been variously quoted as $h_3/h_1 = 0.85$, 0.83, 0.73, and 0.66, the lower figures being more conservative. The submergence limits between $h_3/h_1 = 0.85$ and $h_3/h_1 = 0.66$ are representative for most long-base weirs, although the value $h_3/h_1 = 0.4$ is recommended in Ref. 8-7, p. 104, for a 1:2/1:2 (side slopes of two units horizontal for one unit vertical) Crump weir. Figure 8-13 shows that the submergence limit for thin-plate weirs is very nearly $h_3/h_1 = 0.0$. The drowned performance of thin-plate weirs can be estimated to within a few percent from the Villemonte equation (Ref. 8-76),

$$\frac{Q(\text{submerged})}{Q(h_3/h_1 < 0.8,\ \text{Table 8-16})} = \left[1 - \left(\frac{h_3}{h_1}\right)^n\right]^{0.385}, \tag{8-51}$$

Table 8-16. Weirs.

Notation: b = width of the rectangular channel; C = dimensionless discharge coefficient; g = acceleration due to gravity (Table 3-1); h = fluid depth as shown; ℓ = distance upstream of weir at which depth measurement is made (see text); Q = volume flow rate; U_1 = velocity in approach averaged over the channel area $(h_1 + h_2)b$; δ_* = boundary layer thickness. Consistent sets of units are given in Table 3-1; however, in many frames, the incorporation of dimensioned constants dictates a particular set of units unless these constants are converted to another system. This table was largely adapted from Ref. 8-7. The approach channel is rectangular and contains turbulent, uniformly distributed flow at velocity U_1.

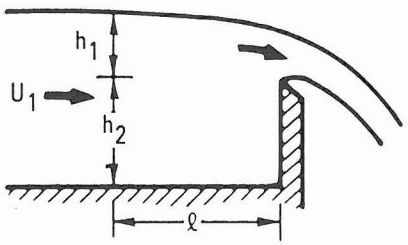
Description	Discharge, Q	Limitations
1. Sharp-Crested Weir in Rectangular Channel  EDGE DETAIL. PLATE MUST BE THICK ENOUGH TO WITHSTAND PRESSURE.	Alternate estimates of Q: $Q = 0.564\left(1 + 0.150\frac{h_1}{h_2}\right) \cdot bg^{1/2}(h_1 + 0.001)^{3/2}$ Ackers, Ref. 8-7, p. 57	meter-sec units. $h_1 > 0.02$ m, $h_2 > 0.15$ m, $h_1/h_2 \le 2.2$
	$Q = \frac{2}{3}\sqrt{2}\left(0.615 + \frac{0.000615}{h_1 + 0.0016}\right) \cdot bg^{1/2} h_1 + 0.5\left(\frac{h_1}{h_1 + h_2}\right)^2 \cdot bg^{1/2} h_1^{3/2}$ Swiss S.I.A. Ref. 8-59	meter-sec units. 0.025 m $< h < 0.8$ m, $b > 0.3$ m, $h_2 > 0.3$ m, $h_1/h_2 < 1.0$
	$Q = \frac{2}{3}\sqrt{2}\left(0.602 + 0.0832\frac{h_1}{h_2}\right) \cdot bg^{1/2}(h_1 + 0.00125)^{3/2}$ Rehbock, Ref. 8-60	meter-sec units. 0.03 m $< h_1 < 0.75$ m, $b > 0.3$ m, $h_2 > 0.3$m, $h_1/h_2 < 1.0$
	$Q = \frac{2}{3}\sqrt{2}\left(0.602 + 0.075\frac{h_1}{h_2}\right) \cdot (b - 0.001)g^{1/2}(h_1 + 0.001)^{3/2}$ Kindswater and Carter, Ref. 8-61	meter-sec units. $h_1 > 0.03$ m, $b > 0.15$ m, $h_2 > 0.1$ m, $h_1/h_2 < 2.0$

Table 8-16. Weirs. *(Continued)*

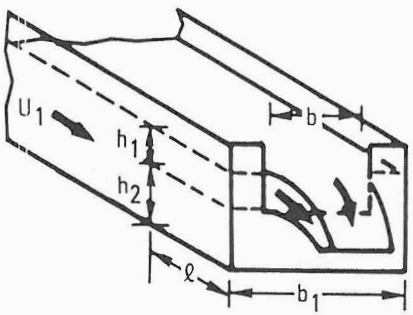
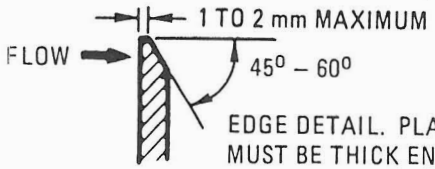
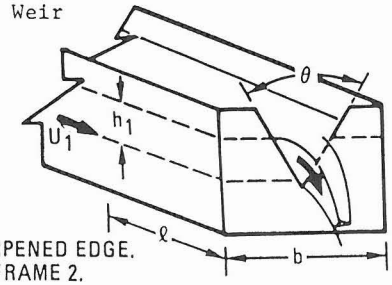
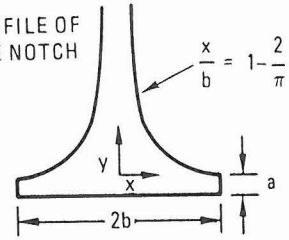
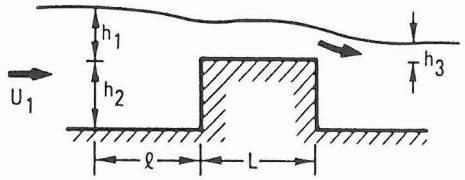
Description	Discharge, Q	Limitations
2. Rectangular Notch, Thin Plate Weir  	Alternate formulas for narrow notches: $Q = 0.581 \left[1 + \frac{0.1}{b}\left(h_1 + 1.4\frac{U_1^2}{2g}\right)\right] \cdot bg^{1/2}\left(h_1 + 1.4\frac{U_1^2}{2g}\right)^{3/2}$ Smith, Ref. 8-62	$(b_1 - b) \geq 4h_1$, $h_1/h_2 < 0/5$, $h_1/b < 0.5$, $0.075\ m < h_1 < 0.6\ m$, $b > 0.3\ m$, $h_2 > 0.3\ m$
	$Q = 0.554\left(1 - 0.0035\frac{h_1}{h_2}\right) \cdot (b + 0.0025)g^{1/2}(h_1 + 0.0001)^{3/2}$ Kindsvater and Carter, Ref. 8-61	meter-sec units, $b/b_1 \leq 0.2$, $h_1/h_2 < 2, b > 0.15\ m$, $h_1 > 0.03\ m$, $h_2 > 0.1\ m$
 EDGE DETAIL. PLATE MUST BE THICK ENOUGH TO WITHSTAND PRESSURE.	Alternate formulas for wide notches: $Q = 0.544\left[1 + 0.064\left(\frac{b}{b_1}\right)^2 + \frac{0.00626 - 0.00519(b/b_1)^2}{h_1 + 0.0016}\right] \cdot \left[1 + 0.5\left(\frac{b}{b_1}\right)^4\left(\frac{h_1}{h_1 + h_2}\right)^2\right] \cdot bg^{1/2}h^{3/2}$ Swiss S.I.A., Ref. 8-59	meter-sec units, $b/B < 0.3$, $h_1/h_2 < 1$, $0.025\ B_1/b\ m < h_1 < 0.8\ m$, $h_2 > 0.3\ m$
	$Q = C\left(1 + \alpha\frac{h_1}{h_2}\right)(b + k) \cdot g^{1/2}(h_1 + 0.001)^{3/2}$, where C, α, and k are functions of b/b_1.	b/b_1 = 1.0, 0.8, 0.6, 0.2–0.0 C = 0.567, 0.562, 0.559, 0.555 α = 0.125, 0.076, 0.030, −0.003 k = −0.001, 0.0042, 0.0035, 0.0025

Table 8-16. Weirs. *(Continued)*

Description	Discharge, Q	Limitations
3. Triangular Notch, Thin Plate Weir  SHARPENED EDGE. SEE FRAME 2.	$Q = C \tan\left(\frac{\theta}{2}\right) g^{1/2}(h_1 + k)^{5/2}$, where C and k are functions of the notch angle θ: θ(Deg) = 20, 40, 60, 80, 90-100 C = 0.59, 0.58, 0.575, 0.575, 0.58 k(m) = 0.0028, 0.0017, 0.0012, 0.001, 0.001 k(ft) = 0.009, 0.0055, 0.004, 0.003, 0.003 Shen, Ref. 8-63	$h_1 \geq 0.05$ m, $h_2 > 0.45$ m, $h_1/h_2 \leq 0.4$ m, $b > 0.9$ m, $\frac{h_1}{b} \tan\left(\frac{\theta}{2}\right) < 2$
4. Proportional Sutro Notch, Thin Plate Weir PROFILE OF THE NOTCH $\frac{x}{b} = 1 - \frac{2}{\pi} \tan^{-1}\left(\frac{y}{a}\right)^{1/2}$  SEE COLUMN 1 OF FRAME 2 OR 3 FOR OVERALL FORM OF WEIR. SEE FRAME 1 FOR EDGE DETAIL.	$Q = 2^{3/2} Ca^{1/2} bg^{1/2} (h_1 - a/3)$ $0.6 < C < 0.7$ Pratt, Ref. 8-64 h_1 = depth of approach flow above base of notch (see frame 2 or 3). Note: Notch is symmetric about y axis. One-half notch shown (i.e., $x > 0$ or $x < 0$) may be used to yield one-half above discharge. Form of notch is fixed by values chosen for a and b.	
5. Long-Base Rectangular Weir  	$Q = \left(\frac{2}{3}\right)^{3/2} Cb\, g^{1/2} \left(h_1 + \frac{U_1^2}{2g}\right)^{3/2}$, where $U_1 = Q/(bh_1)$. The equation must be solved by trial and error for Q given h_1. C is given as follows: C = 0.848 F, where F is a function of h_1/L and $h_1/(h_1 + h_2)$	$h_3/h_1 < 0.8$

$\frac{h_1}{h_1 + h_2}$	F, h_1/L = 0.2	0.4	0.6	0.8	1.0	1.5	2.0
0.350	1.01	1.01	1.05	1.11	1.17	1.28	1.35
0.400	1.02	1.02	1.06	1.11	1.17	1.28	1.34
0.500	1.03	1.04	1.07	1.11	1.17	1.28	1.34
0.600	1.05	1.06	1.08	1.12	1.17	1.27	1.32
0.700	--	1.09	1.11	1.14	1.17	1.24	1.30

Singer and Crabbe, Ref. 8-65

Table 8-16. Weirs. *(Continued)*

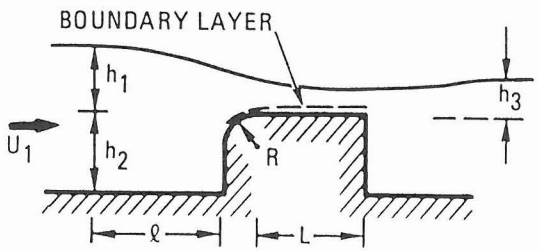
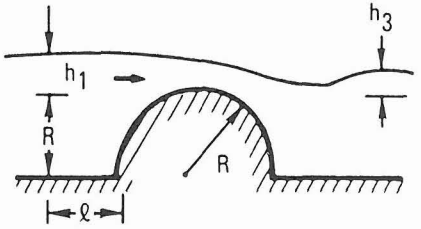
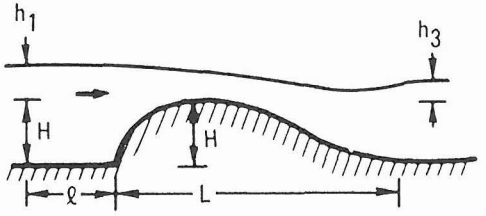
Description	Discharge, Q	Limitations
6. Long-Based, Round-Nosed Weir 	$Q = \frac{2}{3}\sqrt{\frac{2}{3}g}\, Cb\left(h_1 + \frac{U_1^2}{2g}\right)^{3/2}$, where $U = Q/(bh_1)$. The equation must be solved by trial and error for Q given h_1. C is a function of the boundary layer thickness over the weir, δ_l, $C = \left(1 - 2\frac{\delta_l}{L}\frac{L}{b}\right) \cdot \left[1 - \frac{\delta_*}{L}\frac{L}{(h_1 + U_1^2/2g)}\right]^{3/2}$, where δ_l is a function of the Reynolds number, $Re = UL/\nu$ (ν is the kinematic viscosity), and the relative roughness ε/L of the surface of the weir. Values of ε are given in Chapter 6, Table 6-4. Values of δ_l/L are cited in Refs. 8-7, p. 152, and 8-66. For high Reynolds numbers ($UL/\nu > 5 \times 10^6$), $L/\varepsilon = 400$, 10^3, 10^4, 10^5, ∞; $\delta_*/L = 0.009$, 0.0067, 0.0034, 0.002, 0.0015 to 0.002. For most cases, $\delta_l/L \ll 0.01$ and $0.95 < C < 1.00$. Refs. 8-7, pp. 150-156; 8-66	$h_3/h_1 < 0.8$ (See discussion in text.)

Table 8-16. Weirs. *(Continued)*

Description	Discharge, Q	Limitations
7. Semicircular Weir 	$Q = \frac{2}{3}\left(\frac{2}{3}\right)^{1/2} C\, bg^{1/2} h_1^{3/1}$ Ref. 8-67 C is a function of h_1/R h_1/R = 0.1 0.2 0.4 0.6 0.8 1.0 1.2 C = 1.08 1.14 1.18 1.20 1.23 1.30 1.33	$h_3/h_1 < 0.8$
8. Hydrofoil-Shaped Weir 	$Q = \frac{2}{3}\left(\frac{2}{3}\right)^{1/2} C\, bg^{1/2} h^{2/3}$ Ref. 8-67 C is a function of the ratio h_1/L and details of the hydrofoil shape (see Ref. 8-67). Typical values: H/L = 0.1 0.2 0.4 0.6 C = 0.9 1.1 1.2 1.3	$h_3/h_1 < 0.8$

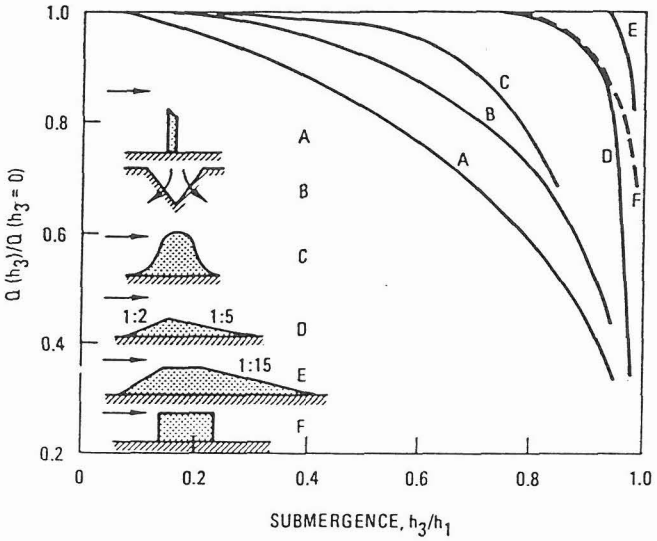


Fig. 8-13. Drowned weir performance. (From Ref. 8-58, reproduced with permission.)

where n is the exponent of the h_1 term in the volume flow rate equation (Table 8-16). $n = 3/2$ for the rectangular thin-plate weir, $n = 5/2$ for the V-notch thin-plate weir, and $n = 1$ for the Sutro proportional thin-plate weir. h_3 is measured downstream beyond the surface disturbance caused by the nappe.

8.4.2. Spillways

The Free Overfall. The free overfall from a rectangular channel can be described in terms of the depth at the brink and the subsequent form of the freely falling nappe (see Fig. 8-14). If the approach flow is subcritical, then the depth must pass through the critical depth (Section 8.2.3) as the flow accelerates into the supercritical free fall. In general, the brink depth is a function of the slope of the channel, the shape of the channel cross section, and the roughness of the channel surface. Rouse (Ref. 8-77) found that the depth at the brink d_b was the fraction $d_b/d_c = 0.715$ of the critical depth d_c for a rectangular channel with slope $S = 0$, as is shown in Fig. 8-14(a). This value is widely accepted (Ref. 8-58).

Delleur et al. (Ref. 8-78) experimentally determined the following brink depths for a smooth rectangular channel with various slopes. The depth at the brink is a function of the channel slope S and the channel slope which is required for critical flow S_c (see Section 8.2):

	← Adverse Slope →				Mild Slope		← Steep Slope →			
S/S_c	−10	−6	−4	−2	0	1	2	4	6	10
d_b/d_c	0.755	0.750	0.745	0.730	0.715	0.680	0.650	0.575	0.525	0.458

d_c is the critical depth. Rajaratnam et al. (Ref. 8-159) have found that the surface roughness of the channel does not influence these depths for roughnesses less than 10% of the critical depth. Larger roughnesses produce somewhat lower depths.

The corresponding results for brink depth in trapezoidal, triangular, circular, and parabolic channels, reviewed in Ref. 8-58, are quantitatively very similar to the above data. The brink depths in an $S = 0$ channel of all the above shapes fall within the range $0.71 < d_d/d_c < 0.77$. The brink depths, relative to the critical depth, increase with adverse slope and decrease with favorable slope.

The nappe falls freely in approximately the parabolic trajectory of a ballistic particle (Ref. 8-1, pp. 360–361). Techniques for accurate prediction of nappe trajectory either are experimental techniques (Refs. 8-1, p. 361; 8-79; 8-80; 8-81) or are somewhat complex analytical techniques (Refs. 8-81, 8-82, 8-83). A number of techniques for predicting the form of a freely falling nappe are reviewed in Refs. 8-1, pp. 361–362, and 8-2, pp. 193–196. It should be cautioned that air will be drawn into the nappe from the cavity formed by the underside of the

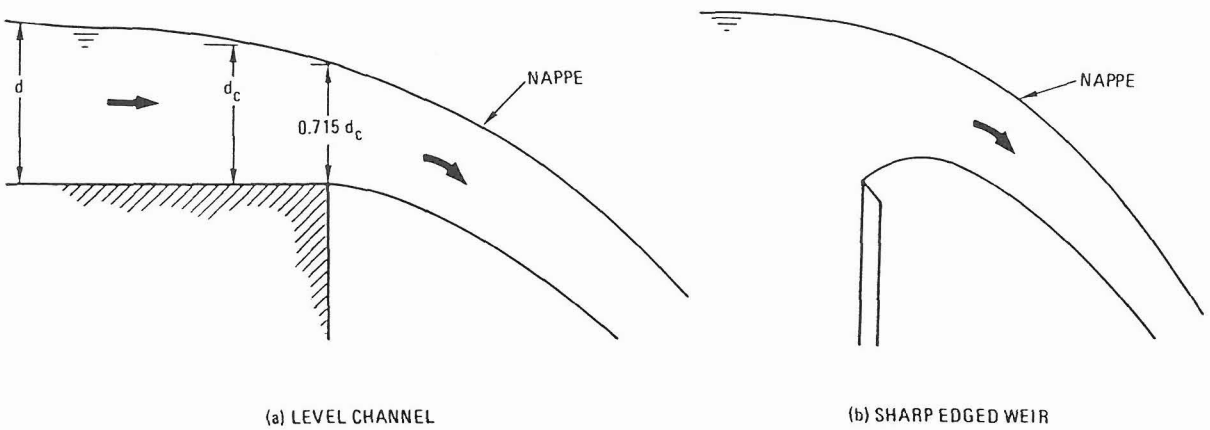


Fig. 8-14. Free overfalls in subcritical flow. d_c is the critical depth. (Ref. 8-77; also Ref. 8-8, p. 529.)

Flexible structures in river and stream training works

Section one
Weirs for river training and water supply

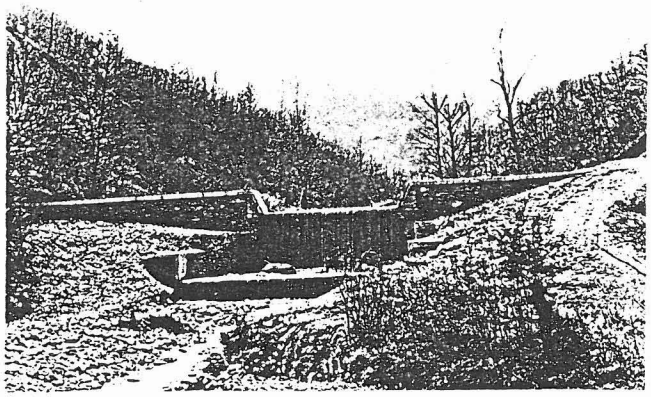
S.P.A. OFFICINE MACCAFERRI - BOLOGNA

dr. eng. Raffaele Agostini
dr. eng. Alberto Bizzarri
dr. eng. Maurizio Masetti

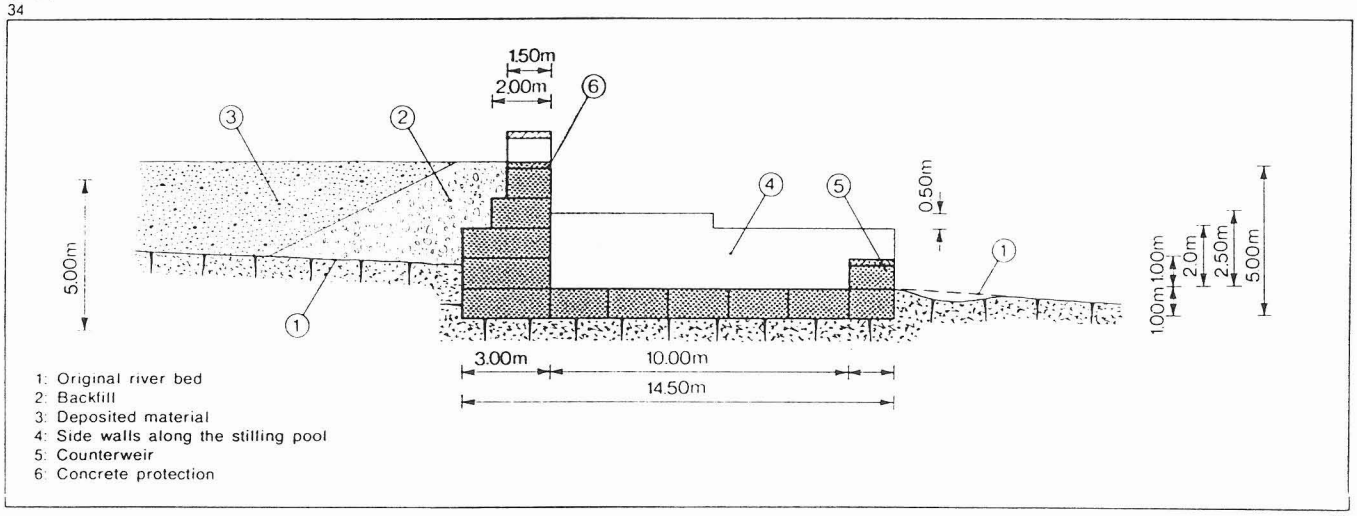
3.2 Stilling pool with lined floor: jump control by broad crested weir

When the river bed consists mainly of loose material of limited size, or when the weir is such that a high degree of security is called for, it will be necessary to line the stilling pool, to prevent the bed from being scoured out.

A type of lined stilling pool is shown in fig. 18. The river bed is protected by a gabion apron, at an elevaion f_b almost coincident with the level f_3 of the river bed; $(f_c - f_3)$ is the height of the counterweir above the apron.



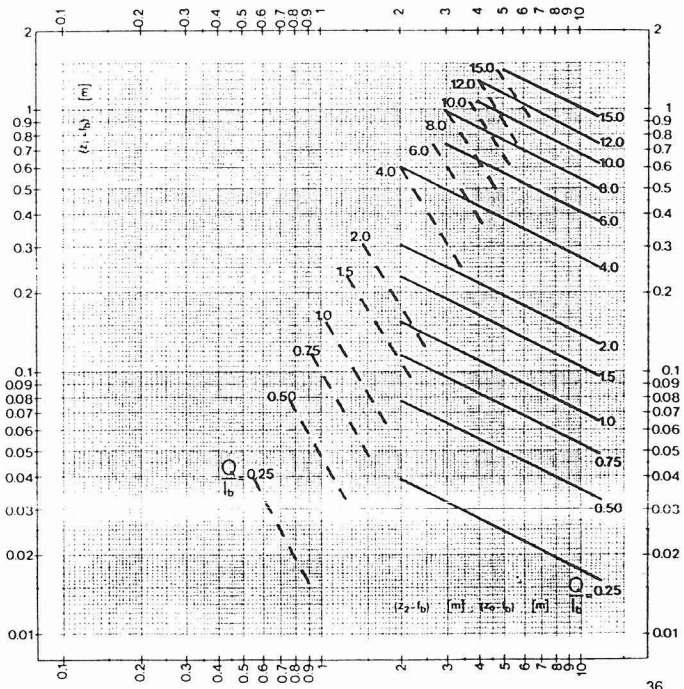
34



35

Figs. 34, 35 - YUGOSLAVIA - S. Giorgio torrent (Istria) - Vertical gabion weir with lined stilling pool and counterwier.

The correct design of the pool requires that critical flow occurs on the counterweir so that the flow of water in the pool is not influenced by the flow downstream of the counterweir. Part of the energy of the water is dissipated immediately downstream of the counterweir and therefore in order to avoid scour of the river bed it is necessary to extend the apron downstream of the counterweir or to key it so deeply into the bed, that its stability is assured even if severe erosion takes place (figs. 34, 35).

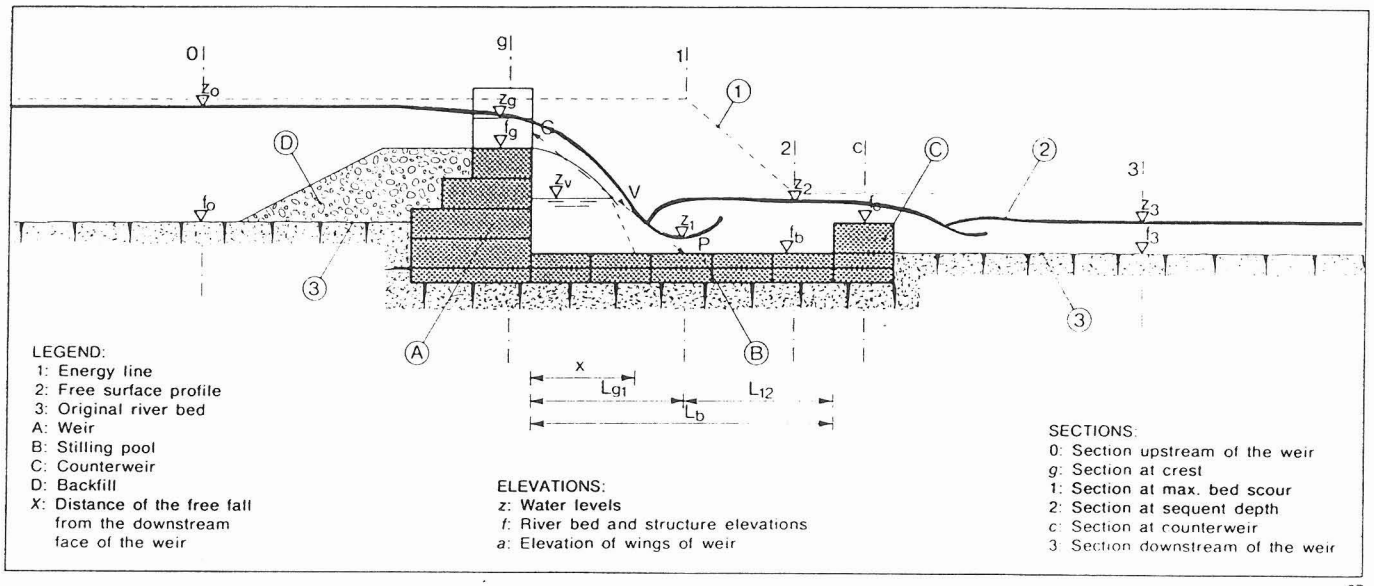


36

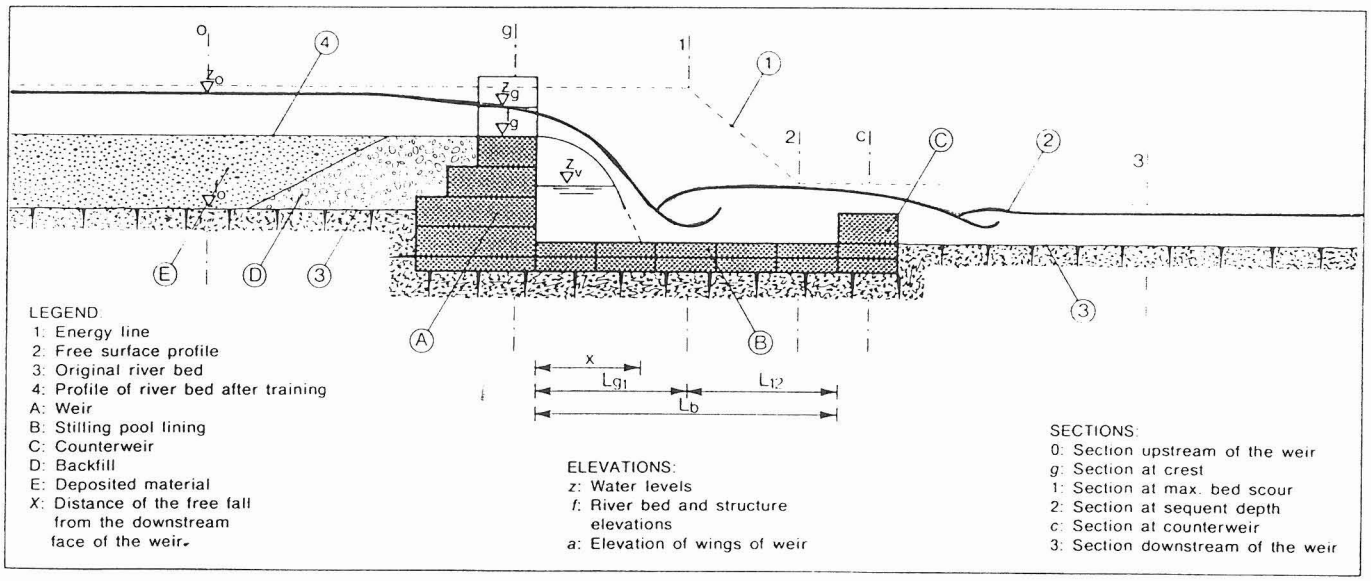
Fig. 36 - Graph of $(z_1 - f_b)$ and $(z_2 - f_b)$.

Fig. 37 - Evaluation of the length of the stilling pool

Fig. 38 - Hydraulic behaviour of a weir backfilled up to crest level.



37



38

The dimensions of the pool are easily calculated using the following methods, since the water flows supercritically, with a depth $(z_1 - f_g)$, in section at the toe of the weir.

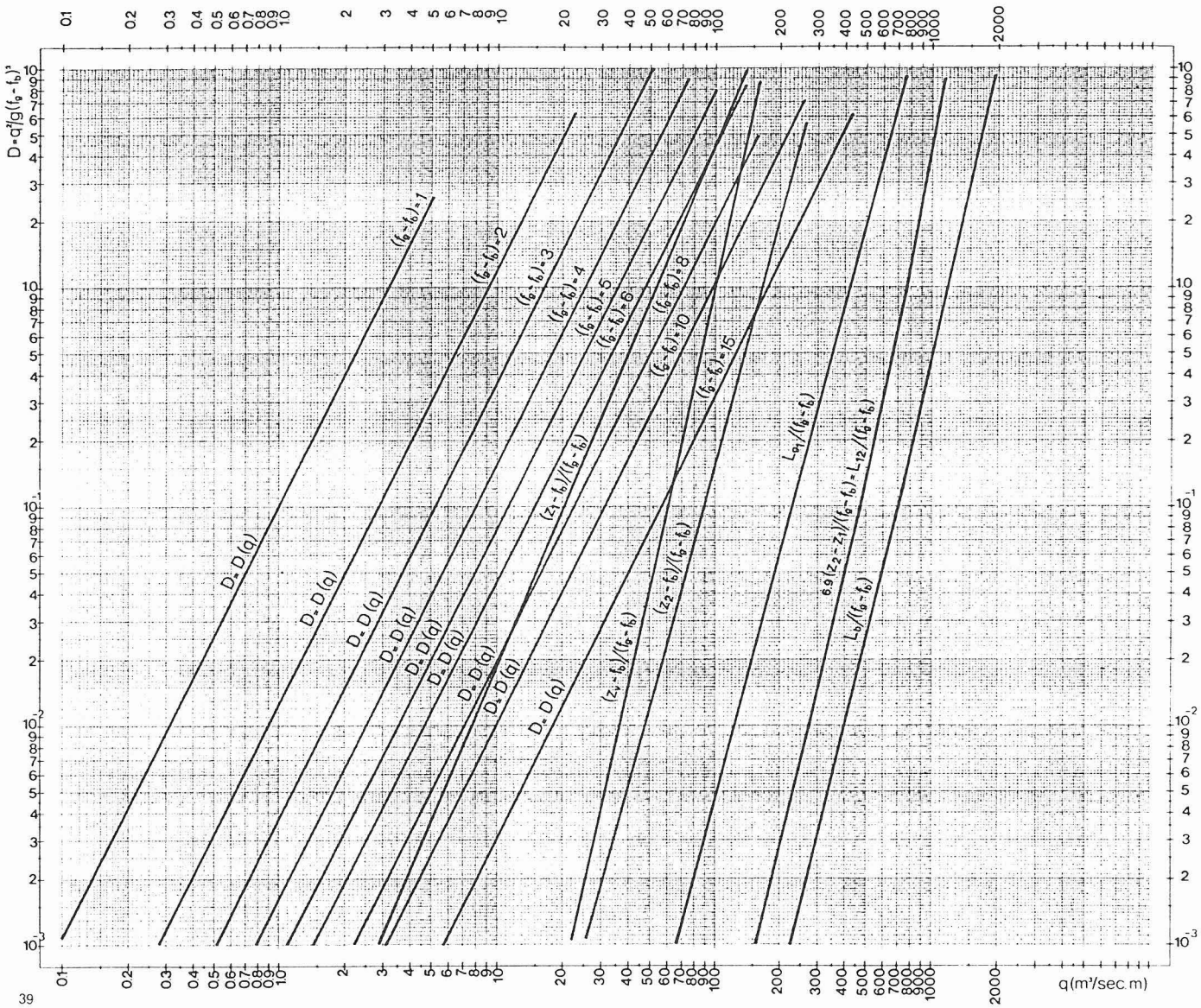
$(z_1 - f_b)$ is obtained from the equation of the hydraulic jump:

$$(8) \qquad (z_0 - f_b) + \frac{Q^2}{2g\Omega_0^2} = (z_1 - f_b) + \frac{Q^2}{2g(z_1 - f_b)^2 l_b^2}$$

since there is no change in the total head between sections 0 and 1. As usual, elevations z_0, f_b and z_1 are in metres, Q is the discharge, in cumecs, Ω_0 is the area of cross section of flow, in m^2, l_b is the width of the pool, in m.

In the above equation of the third degree, $(z_1 - f_b)$ is the unknown value. Generally, both the velocity head $\frac{Q^2}{2g\Omega_0^2}$ and the depth $(z_1 - f_b)$ are small, if compared with the other terms, and can be neglected; depth $(z_1 - f_b)$ is therefore calculated from:

$$(9) \qquad (z_1 - f_b) \simeq \frac{Q}{l_b\sqrt{2g(z_0 - f_b)}}$$



39

Fig. 39 - Dimensions of stilling pool.

The dissipation of energy occurs in the hydraulic jump, which must take place in the protected area between the weir and the counterweir. If $(z_1 - f_b)$ is the relative initial depth of the jump, the relative sequent depth is:

$$(z_2 - f_b) = -\frac{(z_1 - f_b)}{2} + \sqrt{\frac{2Q^2}{g l_b^2 (z_1 - f_b)} + \frac{(z_1 - f_b)^2}{4}} \tag{10}$$

This depth is obtained by means of a broadcrested weir (counterweir) at the end of the stilling pool.

The dimensions of the counterweir can be obtained from equation (6):

$$Q = \mu (z_2 - f_c) l_c \sqrt{2g(z_2 - f_c)} \tag{6}$$

where the unknown quantities are the elevation of the counterweir f_c and its width l_c. Generally, l_c does not differ much from l_b and l_a and therefore f_c can be computed from equation (6), and finally the height $(f_c - f_b)$ of the counterweir can be found.

To simplify calculation, $(z_1 - f_b)$ has been plotted against $(z_0 - f_b)$ and $\frac{Q}{l_b}$, and $(z_1 - f_b)$ has been plotted against $(z_1 - f_b)$ and $\frac{Q}{l_b}$ in fig. 36.

The characteristics of flow downstream of the weir having been established it is necessary to verify that the tailwater does not affect the discharge over the crest. Of course, if submergence caused by the tailwater occurs, the jump is located further upstream, which is a safe condition. But in such case, it would be better to reduce the size of the pool, and to neglect the counterweir.

Another value to be found is the elevation z_v of the water adjacent to the downstream face of the weir. It can be computed approximately from the formula [26]:

$$(z_v - f_b) = (f_g - f_b)\left[\frac{Q^2}{g l_b^2 (f_g - f_b)^3}\right]^{0.22} \tag{11}$$

Length of stilling pool. This is found by adding L_{g1}, the distance of the weir from the position where the subcritical flow of depth $(z_1 - f_b)$ is formed, and L_{12} the length of the portion of pool where the hydraulic jump occurs.

For the computation of L_{g1}, the points G of the axis of the nappe over the crest, V of the axis of the nappe cutting into the water in the pool, and P on the bottom of the pool at section 1, are assumed to be on a straight line (fig. 37).

It is also assumed that the nappe at G is horizontal and its velocity is critical(*); the loss of energy is not considered.

Hence, the projection of $\overline{GV}$ on the horizontal plane is:

$$\overline{V'V} = \sqrt{g(z_g - f_g)}\sqrt{2\left[\frac{f_g + z_g}{2} - z_v\right]}/g =$$
$$= \sqrt{(z_g - f_g)(f_g + z_g - 2z_v)}$$

For the value of z_g see paragraph 2; z_v is obtained from equation (11). Consequently, L_{g1} is:

$$L_{g1} = \overline{GP'}\,\frac{\overline{V'V}}{\overline{GV''}} = \left[\frac{z_g + f_g}{2} - f_b\right]\frac{\sqrt{(z_g - f_g)(f_g + z_g - 2z_v)}}{\frac{z_g + f_g}{2} - z_v}$$

$$L_{g1} = \frac{(z_g + f_g - 2f_b)\sqrt{z_g - f_g}}{\sqrt{z_g + f_g - 2z_v}} \tag{12}$$

Obviously, L_{g1} is greater than the distance X calculated in equation (4). The length of that portion of basin in which the jump occurs:

$$L_{12} = 6.9\,[(z_2 - f_b) - (z_1 - f_b)] = 6.9\,[z_2 - z_1] \tag{13}$$

The total length of the stilling pool is therefore:

$$L_b = L_{g1} + L_{12} = \tag{14}$$
$$= (z_g + f_g - 2f_b)\sqrt{\frac{z_g - f_g}{z_g + f_g - 2z_v}} + 6.9\,(z_2 - z_1)$$

An interesting study can be made of a weir backed by deposited material, up to the level of its (rectangular) crest (fig. 38).

In such a situation, the characteristics of flow can be expressed by simple equation as functions of the drop number D [18].

Such equations were developed by experimental investigations [33], [34], [35].

$$D = q^2/g\,(f_g - f_b)^3 \tag{15}$$

where q is the unit discharge flowing over the crest ($q = Q/l_g$), g is the acceleration due to gravity, and f_g and f_b are shown in fig. 38.

The dimensions of the stilling pool can be derived from the following equations:

$$L_{g1}/(f_g - f_b) = 4.30\,D^{0.27} \tag{16}$$

$$(z_v - f_b)/(f_g - f_b) = 1.00\,D^{0.22} \tag{17}$$

$$(z_1 - f_b)/(f_g - f_b) = 0.54\,D^{0.425} \tag{18}$$

$$(z_2 - f_b)/(f_g - f_b) = 1.66\,D^{0.27} \tag{19}$$

$$L_{12} = 6.9\,(z_2 - z_1) \tag{20}$$

To simplify calculation, the drop number D has been plotted against $(f_g - f_b)$ and q in fig. 39, and the values necessary for dimensioning the stilling pool may be obtained from the curves in fig. 39.

(*) Actually this condition occurs not at the edge of the crest, but upstream of it at a distance of 3-4 times $(z_g - f_g)$. However, such an approximation is sufficient at least for small structures. For important weirs, it is advisable to verify the hydraulic behaviour of the structure using a model.

CHAPTER III

Design criteria for sloped weirs. Construction details

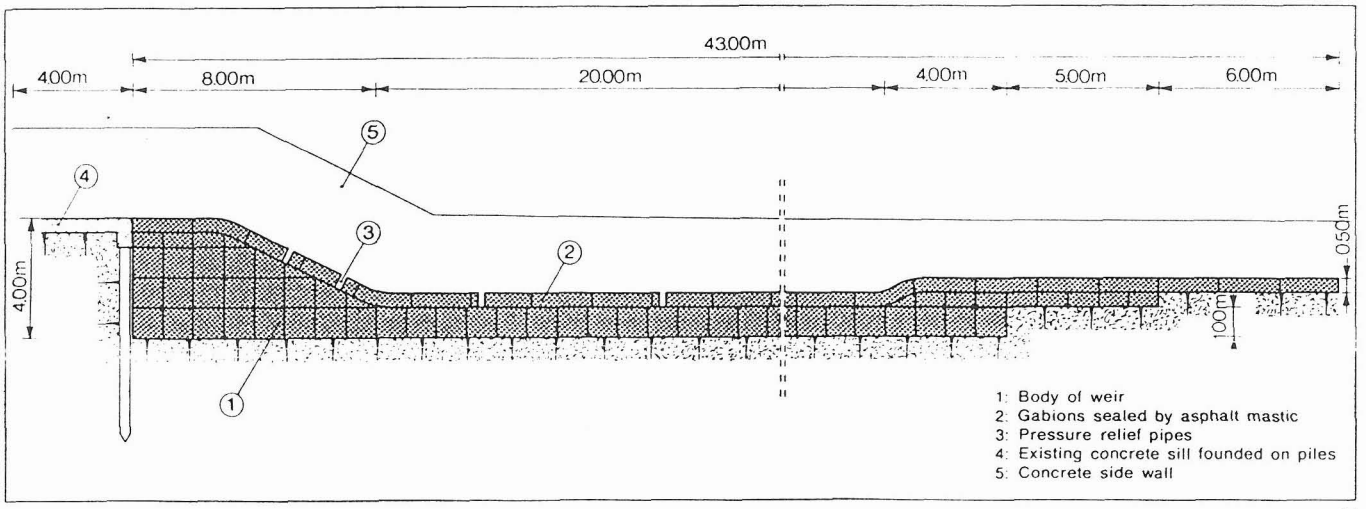
1 General criteria

Generally speaking, weirs with a sloped downstream profile are used for bed stabilization in river training schemes, and as impermeable structures to create storage reservoirs of between 5 and 15 metres deep. Since they have relatively large foundation areas, they are very suitable for heights of less than 5 m on poor soils where a fairly uniform pressure distribution is required. In this connection a weir having both upstream and downstream faces sloped, gives improved statical and hydraulic performances compared to a vertical structure (*).

The crests, downstream glacis and stilling ponds of these weirs are usually faced with an impermeable lining to prevent the migration of soil through the gabions, to protect the wire mesh against abrasion by debris and to consolidate the stone fill which could otherwise be displaced by water at high velocities particularly at the toe. The wing walls which must be high enough to ensure that they are not overtopped, should also be lined or backed by synthetic filter membranes. Concrete can be used for the lining, but a reasonable period, depending on the design of the structures and the foundation soil, should be allowed for any major settlement to take place before it is laid.

(*) The reason for the limiting height of 15 m is an economical and not a technical one. Weirs higher than this should be constructed with a central core of rock or other selected fill [53].

Figs. 54, 55, 56 - Sloped weirs; outer face grouted with sand asphalt mastic.



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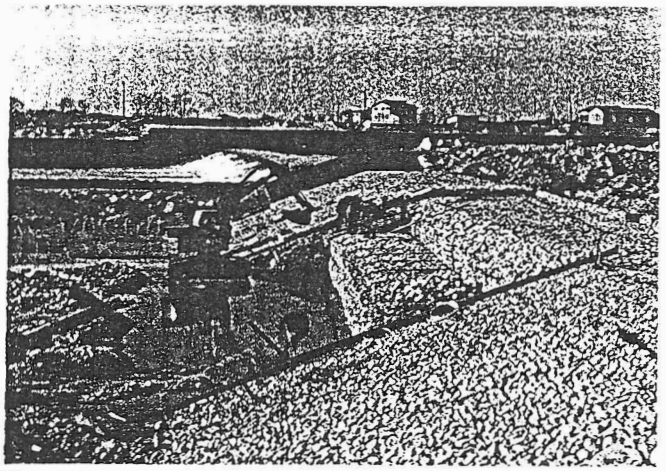
55



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Bituminous sand mastic is preferable in view of its flexibility which allows it to move with any change in the gabion structure, and also because of its greater impermeability: (figs. 54, 55, 56).

Other examples of similar weirs are shown in chapter IV. The design criteria do not differ greatly from those for vertical faced weirs, and only the variations are discussed below.

2 Crest and stilling pool design

The hydraulic calculations for a sloped weir differ from those described in fig. 18 and 19 only because the water does not form a free overfall, but flows down the downstream face. The slope of the glacis is generally 1:2 or 2:3, which is sufficient to guarantee that the flow adheres to the surface even in conditions of high unit discharge.

For the computation of the dimensions of the crest and stilling pool, reference is made to paragraphs 3.1, 3.2, and particularly to equation (3), (6), (8), (10), (21).

The length of the stilling pool is 6.9 $(z_2 - z_1)$; refer to fig. 57.

The subject of seepage is covered in paragraph 5.

THE FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

HEC-2

DIBBLE AND ASSOCIATES CONSULTING ENGINEERS

THE FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

HEC-2 INPUT - SUBCRITICAL FLOW

DIBBLE AND ASSOCIATES CONSULTING ENGINEERS

```
T1 WHITE TANKS #4 FLOOD RETENTION INLET CHANNEL
T2 CONCRETE LINER REVSISIONS            4/11/94
T3      CHANNEL IMPROVE, SUBCRITICAL FLOW  (Q100 = 2206CFS)
T4      STATION 10+79.83 TO 75+00

J1   -10                        .004000              .3    2206
J2    -1                                             -1
J3   100             105             120             150

NC   .04     .04    .025      .1      .3

* This section is extrapolated from survey sections
X1  1000      10     140     226       0       0       0
GR1055.3      82  1055.1      87  1047.4     120  1043.8     140  1043.2     151
GR1040.9     171  1041.2     208  1041.7     226  1045.2     259  1045.6     336

* Sta 10+79.83
* Match Exst Dirt Channel

X1  1080      10     120     259   79.83   79.83   79.83
CI   200 1041.20               2       6   60.00
X3                        158.00 1047.20
X4     1 1047.20  158.00
GR1055.6      82  1055.4      87  1047.7     120  1044.1     140  1043.5     151
GR1041.2     171  1041.5     208  1042.0     226  1045.5     259  1045.9     336

* Sta 11+16.25
* Begin Channel Transition

X1  1116      11     120     260   36.42   36.42   36.42
CI       .000808                           60.00
X3                        158.00 1047.23
X4     1 1047.23  158.00
GR1055.6      82  1055.4      87  1045.0     120  1044.4     140  1043.5     152
GR1041.4     170  1041.6     202  1042.1     209  1042.1     226  1046.1     260
GR1046.1     333

X1  1150      11     119     261   33.75   33.75   33.75
CI                                          61.49
X3                        157.26 1047.26
X4     1 1047.26  157.26
GR1055.5      82  1055.4      87  1045.3     119  1044.7     138  1043.6     155
GR1041.6     165  1041.8     196  1042.6     208  1042.3     227  1046.5     261
GR1046.3     330

X1  1200      11     113     258   50.00   50.00   50.00
CI                                          63.69
X3                        156.16 1047.30
X4     1 1047.30  156.16
GR1055.5      77  1055.3      83  1045.8     113  1045.1     133  1043.9     149
GR1042.0     156  1042.0     192  1042.9     202  1042.6     224  1046.7     258
GR1046.5     329

X1  1250      11     104     249   50.00   50.00   50.00
CI                                          65.90
X3                        155.05 1047.34
X4     1 1047.34  155.05
GR1055.4      69  1055.2      75  1046.5     104  1045.5     124  1044.5     136
GR1042.5     148  1042.2     186  1043.1     192  1043.1     216  1046.8     249
GR1046.6     326

X1  1300      11      64     240   50.00   50.00   50.00
CI                                          68.10
X3                        153.95 1047.38
X4     1 1047.38  153.95
GR1055.5      58  1055.2      64  1046.9      92  1045.9     112  1045.0     123
```

SUBCRIT. INPUT (9½ pages)

```
GR1042.7     143  1043.1     167  1043.0     180  1043.0     197  1047.0     240
GR1046.9     318

X1  1350       9      76     226   50.00   50.00   50.00
CI                                         70.31
X3                         152.85 1047.42
X4     1 1047.42  152.85
GR1055.6      42  1055.3      49  1047.2      76  1046.3      96  1045.6     108
GR1042.8     140  1042.7     164  1047.2     226  1047.2     306

X1  1400       9      75     208   50.00   50.00   50.00
CI                                         72.52
X3                         151.74 1047.46
X4     1 1047.46  151.74
GR1055.6      21  1055.3      29  1048.0      54  1047.2      75  1046.2      96
GR1043.3     119  1043.1     151  1047.6     208  1047.6     292

X1  1456       9      47     181   56.33   56.33   56.33
CI                              2       6   75.00
X3                         150.50 1047.50
X4     1 1047.50  150.50
GR1055.3       0  1048.7      25  1048.0      47  1046.9      63  1045.6      86
GR1043.9      99  1043.7     133  1048.2     181  1048.0     277

* Sta 14+56.33
* End Channel Transition

X1  1495       2       0     400   38.67   38.67   38.67
CI                              2       4   75.00
GR1100.0       0  1100.0     400

* Sta 14+95.00
* End Dirt Channel
* Begin Conc Channel Lining
* Begin Channel Side Slope Transition

NC   .03     .03    .015

X1  1550                           55.00   55.00   55.00
CI                              2       2   65.00

* Sta 15+50.00
* End Channel Side Slope Transition
* Begin Sloped Drop

X1  1560                           10.00   10.00   10.00
CI       1044.83                           65.00

* Sta 15+60.00
* End Sloped Drop
* Begin Grouted Riprap Channel

NC   .04     .04    .028

X1  1580                           20.00   20.00   20.00
CI       .000808                           65.00

* Sta 16+00.00
* Begin Channel Transition

X1  1600                           20.00   20.00   20.00
CI       .000808                           65.00

X1  1650                           50.00   50.00   50.00
CI                                         60.62
```

```
X1  1700                          50.00   50.00   50.00
CI                                        56.25

X1  1750                          50.00   50.00   50.00
CI                                        51.87

X1  1800                          50.00   50.00   50.00
CI                                        47.49

X1  1850                          50.00   50.00   50.00
CI                                        43.12

X1  1900                          50.00   50.00   50.00
CI                                        38.74

X1  1931                          31.29   31.29   31.29
CI       1045.13                          36.00

* Sta 19+31.29
* End Channel Transition
* End Grouted Riprap
* Begin Conc Channel

NC   .03     .03    .015

X1  1950                          18.71   18.71   18.71
CI       .001499

X1  2000                          50.00   50.00   50.00

X1  2050                          50.00   50.00   50.00

X1  2100                          50.00   50.00   50.00

X1  2150                          50.00   50.00   50.00

X1  2200                          50.00   50.00   50.00

X1  2250                          50.00   50.00   50.00

X1  2300                          50.00   50.00   50.00

X1  2350                          50.00   50.00   50.00

X1  2400                          50.00   50.00   50.00

X1  2450                          50.00   50.00   50.00

X1  2500                          50.00   50.00   50.00

X1  2550                          50.00   50.00   50.00

X1  2600                          50.00   50.00   50.00

X1  2650                          50.00   50.00   50.00

X1  2700                          50.00   50.00   50.00

X1  2750                          50.00   50.00   50.00

X1  2800                          50.00   50.00   50.00

X1  2850                          50.00   50.00   50.00

X1  2885                          35.00   35.00   35.00
```

```
* Sloped Drop (28+85.00 to 29+00.00)

X1  2900                          15.00   15.00   15.00
CI       1051.56

X1  2950                          50.00   50.00   50.00
CI       .005000

X1  3000                          50.00   50.00   50.00

X1  3050                          50.00   50.00   50.00

X1  3100                          50.00   50.00   50.00

X1  3150                          50.00   50.00   50.00

X1  3200                          50.00   50.00   50.00

X1  3250                          50.00   50.00   50.00

X1  3300                          50.00   50.00   50.00

X1  3350                          50.00   50.00   50.00

X1  3400                          50.00   50.00   50.00

X1  3450                          50.00   50.00   50.00

X1  3500                          50.00   50.00   50.00

X1  3550                          50.00   50.00   50.00

X1  3600                          50.00   50.00   50.00

X1  3650                          50.00   50.00   50.00

X1  3700                          50.00   50.00   50.00
CI       1055.56

X1  3720                          20.00   20.00   20.00
CI       .022400

X1  3740                          20.00   20.00   20.00

X1  3760                          20.00   20.00   20.00

X1  3780                          20.00   20.00   20.00

X1  3800                          20.00   20.00   20.00
CI       1057.80

X1  3850                          50.00   50.00   50.00
CI       .001493

X1  3900                          50.00   50.00   50.00

X1  3950                          50.00   50.00   50.00

* Sta 40+08.23
* Begin Channel Transition

X1  4008                          58.23   58.23   58.23
CI                                        36.00

X1  4050                          41.77   41.77   41.77
CI                                        44.21
```

```
X1  4100                            50.33   50.33   50.33
CI                                          54.10

* E Q U A T I O N
* Sta 41+00.33 Bk =
* Sta 40+95.00 Ahd

X1  4125                            30.00   30.00   30.00
CI                                          60.00

* Sta 41+25.00
* End Channel Transition

X1  4163                            38.00   38.00   38.00

* Sloped Drop (41+63.00 to 41+75.00)

X1  4175                            12.00   12.00   12.00
CI       1062.42

* Sta 41+90.00
* End Channel Improvements
* Match Exst Wingwalls

NC                                .3      .5

X1  4190       7     133     195      15      15      15
CI                                          .01
X3    10                                                     1100.0  1100.0
GR1069.0     100  1069.0     121  1065.5     133  1062.4  133.01  1062.4  194.99
GR1065.5     195  1069.0     210

X1  4197       7     153     207      11      11      11
X3    10                                                     1100.0  1100.0
GR1068.5     100  1068.1     123  1068.2     153  1062.5  153.01  1062.5  206.99
GR1069.0     207  1069.0     230

* South I-10 Bridge

SB  1.25     1.6      3.      70      54       4     200          1062.7  1062.5
X1  4248       8     153     207      51      51      51
X2                    1.  1066.7    1069
X3    10                                                     1100.0  1100.0
GR1069.0     100  1068.8     123  1068.7     143  1068.6     153  1062.7  153.01
GR1062.7  206.99  1068.1     207  1069.6     229

X1  4300       9     139     197      52      52      52
GR1069.7     100  1069.1     123  1068.2     139  1063.1     146  1063.1     167
GR1063.2     184  1064.5     192  1068.1     197  1072.5     216

NC                                .1      .3

X1  4350       6     133     185      50      50      50
GR1070.0     100  1068.8     133  1063.4     141  1063.4     179  1068.3     185
GR1073.1     216

X1  4400       7     132     184      50      50      50
GR1070.5     100  1069.3     132  1063.8     139  1063.9     159  1063.6     177
GR1068.6     184  1073.6     216

X1  4450       6     132     185      50      50      50
GR1070.9     100  1069.6     132  1064.1     138  1064.0     178  1068.9     185
GR1074.2     216

X1  4500       8     132     183      50      50      50
GR1071.3     100  1070.9     122  1070.0     132  1064.5     137  1064.2     159
```

```
GR1064.2      178  1069.1     183  1074.8     215

X1  4550        8     132     183      50      50      50
GR1071.1      100  1071.2     112  1070.4     132  1064.5     138  1064.5     160
GR1064.5      178  1069.2     183  1075.3     215

X1  4600        7     137     192      50      50      50
GR1072.1      100  1070.6     137  1064.7     145  1064.7     166  1064.7     187
GR1069.5      192  1075.9     215

NC                              .3      .5

X1  4645       14     141     216      45      45      45
GR1072.4      100  1072.0     123  1070.6     141  1066.6     147  1065.5     180
GR1066.2      189  1065.8     195  1066.5     196  1066.8     211  1070.2     216
GR1071.5      227  1073.8     255  1075.7     300  1076.2     350

X1  4660        6     153     207      15      15      15
X3    10                                                    1100.0  1100.0
GR1072.5      100  1073.0     153  1065.0  153.01  1065.0  206.99  1073.0     207
GR1073.0      210

* North I-10 Bridge

SB 1.25       1.6       3      70      54       4     250          1065.3  1065.0
X1  4712        6     153     207      52      52      52
X2                      1  1070.3    1073
X3    10                                                    1100.0  1100.0
GR1072.9      100  1072.5     153  1065.3  153.01  1065.3  206.99  1072.5     207
GR1072.5      215

X1  4733        6     153     207      21      21      21
GR1073.1      100  1067.9     153  1065.4  153.01  1065.4  206.99  1067.9     207
GR1073.0      250

* Exst Sloped Drop (47+33.00 to 47+38.00)

* Sta 47+38.00
* Begin Channel Improvements

X1  4738        2       0     400       5       5       5
CI   200 1067.42                2       2   50.00
GR  1100        0    1100     400

NC                              .1      .3

X1  4750                                12      12      12
CI       .001481

X1  4800                                50      50      50

X1  4850                                50      50      50

X1  4900                                50      50      50

X1  4950                                50      50      50

X1  5000                                50      50      50

X1  5050                                50      50      50

X1  5100                                50      50      50

X1  5120                                20      20      20
CI                              2   .0001   50.00
```

```
X1  5170                                50      50      50

* Sloped Drop (51+70.00 to 51+80.00)

X1  5180                                18      18      18
CI       1071.56

X1  5200                                20      20      20
CI       .007040

* Sta 52+35.00
* End Channel Improvements
* Match Exst Bridge

NC                              .3      .5

X1  5235       6     148     199      35      35      35
CI                                             .01
X3    10                                                        1100.0  1100.0
GR1079.0     100  1081.0     148  1072.0  148.01  1072.0  198.99  1078.2     199
GR1078.2     227

* McDowell Road Bridge

SB  1.05     1.6       3      70      51       3     216          1072.9  1072.0
X1  5323       6     148     199      88      88      88
X2                     1  1077.4    1080
X3    10                                                        1100.0  1100.0
GR1080.4     100  1082.0     148  1072.9  148.01  1072.9  198.99  1079.2     199
GR1078.7     224

* Sta 53+25.00
* Match Exst Bridge
* Begin Channel Improvements
* Begin Channel Transition

X1  5325       2       0     400       2       2       2
CI       1072.94               2   .0001   50.00
GR  1100       0    1100     400

NC                              .1      .3

X1  5350                            25.00   25.00   25.00
CI       .001494               2   .0001   46.80

X1  5400                            50.00   50.00   50.00
CI                              2       2   40.39

X1  5434                            34.27   34.27   34.27
CI                                          36.00

* Sta 54+34.27
* End Channel Transition

X1  5450                            15.73   15.73   15.73

X1  5500                            50.00   50.00   50.00

X1  5544                            43.53   43.53   43.53

* E Q U A T I O N
* Sta 55+43.53 Bk =
* Sta 55+36.64 Ahd

X1  5600                            63.36   63.36   63.36
```

```
X1   5650                                50.00    50.00    50.00

X1   5700                                50.00    50.00    50.00

X1   5750                                50.00    50.00    50.00

X1   5800                                50.00    50.00    50.00

X1   5850                                50.00    50.00    50.00

X1   5885                                35.00    35.00    35.00

* Sloped Drop (58+85.00 to 59+00.00)

X1   5900                                15.00    15.00    15.00
CI        1078.78

X1   5950                                50.00    50.00    50.00
CI        .005000

X1   6000                                50.00    50.00    50.00

X1   6050                                50.00    50.00    50.00

X1   6100                                50.00    50.00    50.00

X1   6150                                50.00    50.00    50.00

X1   6200                                50.00    50.00    50.00

X1   6250                                50.00    50.00    50.00

X1   6300                                50.00    50.00    50.00

X1   6340                                40.00    40.00    40.00
CI        1080.98

X1   6360                                20.00    20.00    20.00
CI        .023300

X1   6380                                20.00    20.00    20.00

X1   6400                                20.00    20.00    20.00

X1   6420                                20.00    20.00    20.00

X1   6440                                20.00    20.00    20.00
CI        1083.31

X1   6460                                20.00    20.00    20.00
CI        .001492

X1   6500                                40.00    40.00    40.00

X1   6540                                40.00    40.00    40.00

X1   6580                                40.00    40.00    40.00

* Sta 66+20.93
* Begin Channel Transition

X1   6621                                40.93    40.93    40.93
CI        1083.58                                 36.00

X1   6650       24      121      157     29.07    29.07    29.07
CI        .013140                                 31.56
```

```
GR1090.2     100  1089.9     108  1089.4     118  1090.2     120  1090.2     121
GR1087.0     127  1085.1     128  1084.6     137  1084.6     146  1087.6     149
GR1090.0     154  1090.3     157  1090.1     171  1089.6     177  1090.2     181
GR1089.3     202  1088.9     205  1090.1     213  1091.0     236  1090.5     264
GR1091.3     270  1091.3     301  1091.6     350  1091.5     400

X1  6700      23     120     157   50.00   50.00   50.00
CI                                         23.92
GR1090.7     100  1090.4     108  1089.8     118  1090.7     120  1087.2     127
GR1085.6     128  1085.0     137  1085.1     145  1088.1     149  1089.2     155
GR1090.9     157  1090.7     171  1089.6     177  1090.7     181  1090.2     203
GR1089.2     206  1090.6     214  1091.6     234  1090.9     260  1091.7     266
GR1091.9     300  1092.2     350  1092.0     400


X1  6752      23     120     157   51.83   51.83   51.83
CI                                         16.00
GR1091.2     100  1090.9     108  1090.2     118  1091.2     120  1087.6     127
GR1086.0     128  1085.5     137  1085.6     145  1088.3     149  1089.5     155
GR1091.0     157  1090.9     170  1090.1     177  1091.1     181  1090.6     200
GR1089.8     206  1091.1     214  1092.0     232  1091.4     261  1092.2     267
GR1092.3     300  1092.6     350  1092.6     400

* Sta 67+51.83
* End Channel Transition
* End Channel Improvements
* End Conc Channel
* Match Exst Dirt Channel

* E Q U A T I O N
* Sta 67+51.83 Bk =
* Sta 67+36.01 Ahd

NC   .04     .04    .025

X1  6800      24     120     156   63.99   63.99   63.99
CI                                           .01
GR1091.6     100  1091.3     107  1090.7     118  1091.6     120  1088.1     126
GR1086.5     128  1086.0     137  1086.1     146  1088.5     149  1089.8     155
GR1091.2     156  1091.1     168  1090.7     178  1091.6     181  1091.2     198
GR1090.4     207  1091.6     213  1092.4     229  1092.0     262  1092.7     269
GR1092.8     301  1093.1     350  1093.1     398  1093.2     404

X1  6900      24     120     155     100     100     100
GR1092.5     100  1092.2     107  1091.7     118  1092.6     120  1088.9     126
GR1087.5     128  1087.1     138  1087.1     147  1088.9     150  1090.4     154
GR1091.4     155  1091.4     166  1091.8     178  1092.4     181  1092.1     194
GR1091.7     207  1092.5     212  1093.1     224  1093.1     264  1093.7     271
GR1093.7     302  1093.9     350  1094.1     396  1094.5     408

X1  7000      24     119     155     100     100     100
GR1093.4     100  1093.1     107  1092.6     117  1093.5     119  1089.8     125
GR1088.4     127  1088.1     138  1088.1     149  1089.3     150  1091.0     154
GR1091.7     155  1091.8     163  1092.8     179  1093.3     180  1093.1     189
GR1092.9     208  1093.5     211  1093.9     219  1094.1     265  1094.8     274
GR1094.5     302  1094.8     350  1095.2     394  1095.7     412

X1  7100      24     119     179     100     100     100
GR1094.3     100  1094.0     106  1093.6     117  1094.5     119  1090.6     125
GR1089.4     127  1089.2     139  1089.1     150  1089.7     151  1091.6     153
GR1091.9     154  1092.1     161  1093.9     179  1094.1     180  1094.0     185
GR1094.2     208  1094.4     210  1094.6     214  1095.2     267  1095.8     276
GR1095.4     303  1095.6     350  1096.2     392  1097.0     416

X1  7200      18     119     180     100     100     100
GR1095.2     100  1094.9     106  1094.5     117  1095.4     119  1091.5     124
```

```
GR1090.3     127  1090.2     139  1090.1     151  1092.2     153  1092.5     158
GR1095.0     180  1095.4     209  1096.3     269  1096.8     279  1096.3     304
GR1096.5     350  1097.3     390  1098.2     420

X1  7300      20     120     181     100     100     100
GR1096.0     100  1095.7     106  1095.1     118  1096.0     120  1096.0     120
GR1092.4     125  1091.2     128  1091.1     140  1091.1     152  1093.1     154
GR1093.5     159  1095.7     181  1096.0     206  1095.9     209  1096.9     269
GR1097.5     282  1097.2     308  1097.4     350  1097.6     392  1098.3     416

X1  7400      20     121     182     100     100     100
GR1096.7     100  1096.5     106  1095.7     118  1096.7     121  1096.6     121
GR1093.3     127  1092.2     129  1092.0     141  1092.1     153  1094.0     155
GR1094.5     160  1096.4     182  1096.6     203  1096.3     208  1097.4     269
GR1098.2     285  1098.1     312  1098.3     350  1097.9     394  1098.5     412

X1  7500      20     123     182     100     100     100
GR1097.5     100  1097.3     106  1096.4     119  1097.3     121  1097.3     123
GR1094.3     128  1093.1     130  1092.9     142  1093.0     153  1094.8     155
GR1095.5     162  1097.1     182  1097.3     201  1096.8     208  1098.0     270
GR1098.9     289  1099.0     316  1099.1     350  1098.3     396  1098.6     408

EJ
ER
```

THE FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

HEC-2 OUTPUT (SUMMARY TABLES)
SUBCRITICAL FLOW

DIBBLE AND ASSOCIATES CONSULTING ENGINEERS

```
*******************************************
*  HEC-2 WATER SURFACE PROFILES           *
*                                         *
*  Version   4.6.2;  May 1991             *
*                                         *
*  RUN DATE    27JUL94    TIME   22:18:00 *
*******************************************
```

```
****************************************
*  U.S. ARMY CORPS OF ENGINEERS        *
*  HYDROLOGIC ENGINEERING CENTER       *
*  609 SECOND STREET, SUITE D          *
*  DAVIS, CALIFORNIA 95616-4687        *
*          (916) 756-1104              *
****************************************
```

```
X     X  XXXXXXX   XXXXX              XXXXX
X     X  X        X     X            X     X
X     X  X        X                        X
XXXXXXX  XXXX     X          XXXXX    XXXXX
X     X  X        X                   X
X     X  X        X     X             X
X     X  XXXXXXX   XXXXX              XXXXXXX
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THIS RUN EXECUTED 27JUL94 22:18:00

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************************************
 HEC-2 WATER SURFACE PROFILES

 Version   4.6.2;  May 1991
************************************
```

```
T1 WHITE TANKS #4 FLOOD RETENTION INLET CHANNEL
T2 CONCRETE LINER REVSISIONS            4/11/94
T3      CHANNEL IMPROVE, SUBCRITICAL FLOW  (Q100 = 2206CFS)
T4      STATION 10+79.83 TO 75+00

J1  ICHECK    INQ       NINV      IDIR      STRT      METRIC    HVINS     Q         WSEL      FQ
     -10                                   .004000                  .3      2206

J2  NPROF     IPLOT     PRFVS     XSECV     XSECH     FN        ALLDC     IBW       CHNIM     ITRACE
     -1                                                           -1

J3  VARIABLE CODES FOR SUMMARY PRINTOUT
    100                 105                 120                 150
```

THIS RUN EXECUTED 27JUL94 22:18:19

****
HEC-2 WATER SURFACE PROFILES

Version 4.6.2; May 1991
****

NOTE- ASTERISK (*) AT LEFT OF CROSS-SECTION NUMBER INDICATES MESSAGE IN SUMMARY OF ERRORS LIST

CHANNEL IMPROVE, SUBCRIT

SUMMARY PRINTOUT TABLE 100

	SECNO	EGLWC	ELLC	EGPRS	ELTRD	QPR	QWEIR	CLASS	H3	DEPTH	CWSEL	VCH	EG
*	4248.000	1068.78	1066.70	1069.24	1069.00	2184.00	16.34	30.00	.00	5.68	1068.38	7.19	1069.18
	4712.000	1071.58	1070.30	1072.19	1073.00	2206.00	.00	10.00	.43	6.21	1071.51	6.58	1072.19
*	5323.000	1079.12	1077.40	1078.46	1080.00	2206.00	.00	2.00	.00	5.10	1078.00	8.49	1079.12

CHANNEL IMPROVE, SUBCRIT

SUMMARY PRINTOUT TABLE 105

	SECNO	CWSEL	HL	OLOSS	TOPWID	QLOB	QCH	QROB
*	4190.000	1065.80	.04	.09	62.00	.00	2206.00	.00
*	4197.000	1066.22	.03	.09	53.99	.00	2206.00	.00
*	4248.000	1068.38	1.09	.00	54.00	.00	2206.00	.00
	4300.000	1068.26	.04	.16	59.99	.00	2206.00	.00
	4645.000	1070.14	.06	.08	74.23	.00	2206.00	.00
	4660.000	1070.25	.02	.02	53.99	.00	2206.00	.00
	4712.000	1071.51	.99	.00	54.00	.00	2206.00	.00
	4733.000	1071.76	.01	.05	125.90	106.22	2012.04	87.74
*	5200.000	1075.51	.05	.00	57.63	.00	2206.00	.00
*	5235.000	1075.87	.09	.07	50.99	.00	2206.00	.00
*	5323.000	1078.00	1.31	.00	50.99	.00	2206.00	.00
	5325.000	1078.37	.00	.09	60.86	.00	2206.00	.00

CHANNEL IMPROVE, SUBCRIT

SUMMARY PRINTOUT TABLE 120

	SECNO	CWSEL	EG	VCH	10*KS	DEPTH	TOPWID	CLSTA	BW	STCHL	XLBEL	STCHR	RBEL
	1000.000	1044.72	1045.64	7.92	40.44	3.82	119.56	.00	.01	140.00	1043.80	226.00	1041.70
	1080.000	1045.06	1045.95	7.57	35.72	3.86	92.56	200.00	60.00	120.00	1047.70	259.00	1045.50
	1116.000	1045.29	1046.08	7.12	29.20	4.06	92.50	200.00	60.00	120.00	1047.23	260.00	1046.10
	1150.000	1045.55	1046.17	6.35	21.32	4.29	96.94	200.00	61.49	119.00	1047.26	262.18	1046.50
	1200.000	1045.69	1046.28	6.18	19.90	4.39	98.82	200.00	63.69	113.00	1047.30	264.16	1046.68
	1250.000	1045.85	1046.38	5.81	16.92	4.52	102.05	200.00	65.90	104.00	1047.34	265.47	1046.76
	1300.000	1045.99	1046.46	5.53	14.83	4.61	105.00	200.00	68.10	64.00	1055.20	267.57	1046.96
	1350.000	1046.10	1046.54	5.29	13.25	4.69	107.80	200.00	70.31	76.00	1047.42	269.85	1047.20
	1400.000	1046.20	1046.60	5.08	12.00	4.74	110.48	200.00	72.52	75.00	1047.46	273.11	1047.60
	1456.000	1046.30	1046.67	4.88	10.87	4.80	113.38	200.00	75.00	47.00	1048.00	276.48	1048.00
	1495.000	1046.32	1046.73	5.15	11.61	4.78	103.73	200.00	75.00	.00	1100.00	400.00	1082.16
	1550.000	1046.20	1046.84	6.43	6.61	4.62	83.49	200.00	65.00	.00	1100.00	400.00	1100.00
*	1560.000	1048.01	1049.48	9.74	23.78	3.18	77.70	200.00	65.00	.00	1100.00	400.00	1100.00
*	1580.000	1048.50	1049.58	8.36	51.67	3.65	79.60	200.00	65.00	.00	1100.00	400.00	1100.00
	1600.000	1048.74	1049.69	7.82	42.07	3.88	80.51	200.00	65.00	.00	1100.00	400.00	1100.00
	1650.000	1048.92	1049.91	7.99	42.41	4.02	76.71	200.00	60.62	.00	1100.00	400.00	1100.00
	1700.000	1049.10	1050.15	8.22	43.74	4.15	72.87	200.00	56.25	.00	1100.00	400.00	1100.00
	1750.000	1049.27	1050.39	8.52	45.89	4.28	69.01	200.00	51.87	.00	1100.00	400.00	1100.00
	1800.000	1049.44	1050.66	8.87	48.86	4.41	65.15	200.00	47.49	.00	1100.00	400.00	1100.00
	1850.000	1049.61	1050.95	9.30	52.87	4.54	61.30	200.00	43.12	.00	1100.00	400.00	1100.00
	1900.000	1049.78	1051.27	9.81	58.26	4.67	57.44	200.00	38.74	.00	1100.00	400.00	1100.00
	1931.000	1049.88	1051.50	10.20	62.77	4.75	55.01	200.00	36.00	.00	1100.00	400.00	1100.00
*	1950.000	1050.10	1051.56	9.72	15.65	4.94	55.78	200.00	36.00	.00	1100.00	400.00	1100.00
	2000.000	1050.17	1051.64	9.73	15.72	4.94	55.76	200.00	36.00	.00	1100.00	400.00	1100.00

	SECNO	CWSEL	EG	VCH	10*KS	DEPTH	TOPWID	CLSTA	BW	STCHL	XLBEL	STCHR	RBEL
	2050.000	1050.25	1051.72	9.73	15.72	4.94	55.76	200.00	36.00	.00	1100.00	400.00	1100.00
	2100.000	1050.33	1051.80	9.72	15.67	4.95	55.77	200.00	36.00	.00	1100.00	400.00	1100.00
	2150.000	1050.42	1051.88	9.71	15.60	4.96	55.80	200.00	36.00	.00	1100.00	400.00	1100.00
	2200.000	1050.50	1051.96	9.69	15.51	4.97	55.83	200.00	36.00	.00	1100.00	400.00	1100.00
	2250.000	1050.59	1052.04	9.67	15.40	4.98	55.87	200.00	36.00	.00	1100.00	400.00	1100.00
	2300.000	1050.67	1052.11	9.64	15.30	4.99	55.91	200.00	36.00	.00	1100.00	400.00	1100.00
	2350.000	1050.75	1052.19	9.62	15.20	5.00	55.95	200.00	36.00	.00	1100.00	400.00	1100.00
	2400.000	1050.84	1052.27	9.60	15.10	5.00	55.98	200.00	36.00	.00	1100.00	400.00	1100.00
	2450.000	1050.92	1052.34	9.58	15.03	5.01	56.01	200.00	36.00	.00	1100.00	400.00	1100.00
	2500.000	1051.00	1052.42	9.57	14.96	5.01	56.04	200.00	36.00	.00	1100.00	400.00	1100.00
	2550.000	1051.07	1052.49	9.56	14.91	5.02	56.05	200.00	36.00	.00	1100.00	400.00	1100.00
	2600.000	1051.15	1052.57	9.55	14.88	5.02	56.07	200.00	36.00	.00	1100.00	400.00	1100.00
	2650.000	1051.23	1052.64	9.55	14.86	5.02	56.07	200.00	36.00	.00	1100.00	400.00	1100.00
	2700.000	1051.30	1052.72	9.55	14.85	5.02	56.08	200.00	36.00	.00	1100.00	400.00	1100.00
	2750.000	1051.38	1052.79	9.55	14.85	5.02	56.08	200.00	36.00	.00	1100.00	400.00	1100.00
	2800.000	1051.45	1052.87	9.55	14.86	5.02	56.08	200.00	36.00	.00	1100.00	400.00	1100.00
	2850.000	1051.52	1052.94	9.55	14.87	5.02	56.07	200.00	36.00	.00	1100.00	400.00	1100.00
	2885.000	1051.58	1052.99	9.55	14.88	5.02	56.07	200.00	36.00	.00	1100.00	400.00	1100.00
*	2900.000	1056.02	1057.90	11.01	22.55	4.46	53.84	200.00	36.00	.00	1100.00	400.00	1100.00
*	2950.000	1056.27	1058.15	11.00	22.50	4.46	53.85	200.00	36.00	.00	1100.00	400.00	1100.00
*	3000.000	1056.52	1058.40	11.00	22.50	4.46	53.85	200.00	36.00	.00	1100.00	400.00	1100.00
*	3050.000	1056.77	1058.65	11.00	22.50	4.46	53.85	200.00	36.00	.00	1100.00	400.00	1100.00
*	3100.000	1057.02	1058.90	11.00	22.50	4.46	53.85	200.00	36.00	.00	1100.00	400.00	1100.00
*	3150.000	1057.27	1059.15	11.00	22.50	4.46	53.85	200.00	36.00	.00	1100.00	400.00	1100.00
*	3200.000	1057.52	1059.40	11.00	22.50	4.46	53.85	200.00	36.00	.00	1100.00	400.00	1100.00
*	3250.000	1057.77	1059.65	11.00	22.50	4.46	53.85	200.00	36.00	.00	1100.00	400.00	1100.00

	SECNO	CWSEL	EG	VCH	10*KS	DEPTH	TOPWID	CLSTA	BW	STCHL	XLBEL	STCHR	RBEL
*	3300.000	1058.02	1059.90	11.00	22.50	4.46	53.85	200.00	36.00	.00	1100.00	400.00	1100.00
*	3350.000	1058.27	1060.15	11.00	22.50	4.46	53.85	200.00	36.00	.00	1100.00	400.00	1100.00
*	3400.000	1058.52	1060.40	11.00	22.50	4.46	53.85	200.00	36.00	.00	1100.00	400.00	1100.00
*	3450.000	1058.77	1060.65	11.00	22.50	4.46	53.85	200.00	36.00	.00	1100.00	400.00	1100.00
*	3500.000	1059.02	1060.90	11.00	22.50	4.46	53.85	200.00	36.00	.00	1100.00	400.00	1100.00
*	3550.000	1059.27	1061.15	11.00	22.50	4.46	53.85	200.00	36.00	.00	1100.00	400.00	1100.00
*	3600.000	1059.52	1061.40	11.00	22.50	4.46	53.85	200.00	36.00	.00	1100.00	400.00	1100.00
*	3650.000	1059.77	1061.65	11.00	22.50	4.46	53.85	200.00	36.00	.00	1100.00	400.00	1100.00
*	3700.000	1060.02	1061.90	11.00	22.50	4.46	53.85	200.00	36.00	.00	1100.00	400.00	1100.00
*	3720.000	1060.47	1062.35	11.00	22.50	4.46	53.85	200.00	36.00	.00	1100.00	400.00	1100.00
*	3740.000	1060.92	1062.80	11.00	22.50	4.46	53.85	200.00	36.00	.00	1100.00	400.00	1100.00
*	3760.000	1061.37	1063.25	11.00	22.50	4.46	53.85	200.00	36.00	.00	1100.00	400.00	1100.00
*	3780.000	1061.81	1063.69	11.00	22.50	4.46	53.85	200.00	36.00	.00	1100.00	400.00	1100.00
*	3800.000	1062.26	1064.14	11.00	22.50	4.46	53.85	200.00	36.00	.00	1100.00	400.00	1100.00
	3850.000	1062.76	1064.27	9.88	16.40	4.89	55.52	200.00	36.00	.00	1100.00	400.00	1100.00
	3900.000	1062.85	1064.36	9.85	16.28	4.90	55.56	200.00	36.00	.00	1100.00	400.00	1100.00
	3950.000	1062.99	1064.44	9.67	15.44	4.96	55.86	200.00	36.00	.00	1100.00	400.00	1100.00
	4008.000	1063.08	1064.53	9.67	15.44	4.97	55.86	200.00	36.00	.00	1100.00	400.00	1100.00
*	4050.000	1063.89	1064.64	6.94	6.49	5.72	67.07	200.00	44.21	.00	1100.00	400.00	1100.00
	4100.000	1064.20	1064.69	5.61	3.88	5.96	77.93	200.00	54.10	.00	1100.00	400.00	1100.00
	4125.000	1064.31	1064.71	5.09	3.10	6.02	84.07	200.00	60.00	.00	1100.00	400.00	1100.00
	4163.000	1064.32	1064.73	5.14	3.19	5.97	83.86	200.00	60.00	.00	1100.00	400.00	1100.00
*	4175.000	1065.76	1067.28	9.92	23.47	3.34	73.35	200.00	60.00	.00	1100.00	400.00	1100.00
*	4190.000	1065.80	1067.50	10.46	24.76	3.40	62.00	.00	.01	133.00	1065.50	195.00	1065.50
*	4197.000	1066.22	1068.09	10.99	25.34	3.72	53.99	.00	.01	153.00	1068.20	207.00	1069.00
*	4248.000	1068.38	1069.18	7.19	6.67	5.68	54.00	.00	.01	153.00	1068.60	207.00	1068.10

	SECNO	CWSEL	EG	VCH	10*KS	DEPTH	TOPWID	CLSTA	BW	STCHL	XLBEL	STCHR	RBEL
	4300.000	1068.26	1069.39	8.51	10.71	5.16	59.99	.00	.01	139.00	1068.20	197.00	1068.10
*	4350.000	1067.85	1069.82	11.26	22.58	4.45	50.05	.00	.01	133.00	1068.80	185.00	1068.30
*	4400.000	1068.23	1070.20	11.28	22.81	4.63	50.11	.00	.01	132.00	1069.30	184.00	1068.60
*	4450.000	1068.39	1070.33	11.17	22.55	4.39	50.96	.00	.01	132.00	1069.60	185.00	1068.90
*	4500.000	1068.60	1070.59	11.33	22.97	4.40	49.22	.00	.01	132.00	1070.00	183.00	1069.10
*	4550.000	1068.86	1070.86	11.37	23.07	4.36	49.07	.00	.01	132.00	1070.40	183.00	1069.20
	4600.000	1069.73	1071.02	9.12	12.44	5.03	54.68	.00	.01	137.00	1070.60	192.00	1069.50
	4645.000	1070.14	1071.16	8.09	12.30	4.64	74.23	.00	.01	141.00	1070.60	216.00	1070.20
	4660.000	1070.25	1071.19	7.79	8.60	5.25	53.99	.00	.01	153.00	1073.00	207.00	1073.00
	4712.000	1071.51	1072.19	6.58	5.08	6.21	54.00	.00	.01	153.00	1072.50	207.00	1072.50
	4733.000	1071.76	1072.25	5.86	3.34	6.36	125.90	.00	.01	153.00	1067.90	207.00	1067.90
*	4738.000	1071.22	1072.79	10.07	21.29	3.80	65.21	200.00	50.00	.00	1100.00	400.00	1100.00
	4750.000	1071.24	1072.82	10.08	21.34	3.81	65.20	200.00	50.00	.00	1100.00	400.00	1100.00
	4800.000	1071.60	1072.94	9.28	16.61	4.09	66.35	200.00	50.00	.00	1100.00	400.00	1100.00
	4850.000	1071.73	1073.02	9.13	15.84	4.14	66.58	200.00	50.00	.00	1100.00	400.00	1100.00
	4900.000	1071.81	1073.10	9.14	15.86	4.15	66.57	200.00	50.00	.00	1100.00	400.00	1100.00
	4950.000	1071.89	1073.18	9.12	15.80	4.16	66.59	200.00	50.00	.00	1100.00	400.00	1100.00
	5000.000	1072.01	1073.26	8.99	15.11	4.20	66.80	200.00	50.00	.00	1100.00	400.00	1100.00
	5050.000	1072.08	1073.34	8.99	15.12	4.20	66.80	200.00	50.00	.00	1100.00	400.00	1100.00
	5100.000	1072.16	1073.42	8.99	15.11	4.20	66.81	200.00	50.00	.00	1100.00	400.00	1100.00
	5120.000	1071.87	1073.59	10.54	22.65	3.88	57.77	200.00	50.00	.00	1100.00	400.00	1100.00
	5170.000	1072.28	1073.72	9.62	17.09	4.22	58.46	200.00	50.00	.00	1100.00	400.00	1100.00
*	5180.000	1075.37	1077.17	10.76	24.14	3.81	57.62	200.00	50.00	.00	1100.00	400.00	1100.00
*	5200.000	1075.51	1077.31	10.75	24.06	3.81	57.63	200.00	50.00	.00	1100.00	400.00	1100.00
*	5235.000	1075.87	1077.81	11.18	25.27	3.87	50.99	.00	.01	148.00	1081.00	199.00	1078.20
*	5323.000	1078.00	1079.12	8.49	10.67	5.10	50.99	.00	.01	148.00	1082.00	199.00	1079.20

	SECNO	CWSEL	EG	VCH	10*KS	DEPTH	TOPWID	CLSTA	BW	STCHL	XLBEL	STCHR	RBEL
	5325.000	1078.37	1079.20	7.33	7.48	5.43	60.86	200.00	50.00	.00	1100.00	400.00	1100.00
	5350.000	1078.28	1079.27	7.98	9.22	5.30	57.41	200.00	46.80	.00	1100.00	400.00	1100.00
	5400.000	1078.27	1079.34	8.31	10.52	5.22	61.27	200.00	40.39	.00	1100.00	400.00	1100.00
	5434.000	1078.04	1079.51	9.73	15.70	4.93	55.77	200.00	36.00	.00	1100.00	400.00	1100.00
	5450.000	1078.06	1079.53	9.75	15.78	4.93	55.74	200.00	36.00	.00	1100.00	400.00	1100.00
	5500.000	1078.14	1079.61	9.75	15.81	4.93	55.73	200.00	36.00	.00	1100.00	400.00	1100.00
	5544.000	1078.21	1079.68	9.75	15.78	4.94	55.74	200.00	36.00	.00	1100.00	400.00	1100.00
	5600.000	1078.32	1079.78	9.72	15.65	4.95	55.78	200.00	36.00	.00	1100.00	400.00	1100.00
	5650.000	1078.40	1079.86	9.69	15.50	4.97	55.84	200.00	36.00	.00	1100.00	400.00	1100.00
	5700.000	1078.49	1079.94	9.67	15.40	4.98	55.87	200.00	36.00	.00	1100.00	400.00	1100.00
	5750.000	1078.57	1080.02	9.64	15.30	4.99	55.91	200.00	36.00	.00	1100.00	400.00	1100.00
	5800.000	1078.66	1080.09	9.62	15.19	5.00	55.95	200.00	36.00	.00	1100.00	400.00	1100.00
	5850.000	1078.74	1080.17	9.60	15.10	5.00	55.98	200.00	36.00	.00	1100.00	400.00	1100.00
	5885.000	1078.80	1080.22	9.58	15.01	5.01	56.02	200.00	36.00	.00	1100.00	400.00	1100.00
*	5900.000	1083.24	1085.12	11.01	22.56	4.46	53.84	200.00	36.00	.00	1100.00	400.00	1100.00
*	5950.000	1083.49	1085.37	11.00	22.47	4.46	53.86	200.00	36.00	.00	1100.00	400.00	1100.00
*	6000.000	1083.74	1085.62	11.00	22.48	4.46	53.85	200.00	36.00	.00	1100.00	400.00	1100.00
*	6050.000	1083.99	1085.87	11.00	22.50	4.46	53.85	200.00	36.00	.00	1100.00	400.00	1100.00
*	6100.000	1084.24	1086.12	11.00	22.50	4.46	53.85	200.00	36.00	.00	1100.00	400.00	1100.00
*	6150.000	1084.49	1086.37	11.00	22.50	4.46	53.85	200.00	36.00	.00	1100.00	400.00	1100.00
*	6200.000	1084.74	1086.62	11.00	22.50	4.46	53.85	200.00	36.00	.00	1100.00	400.00	1100.00
*	6250.000	1084.99	1086.87	11.00	22.50	4.46	53.85	200.00	36.00	.00	1100.00	400.00	1100.00
*	6300.000	1085.24	1087.12	11.00	22.50	4.46	53.85	200.00	36.00	.00	1100.00	400.00	1100.00
*	6340.000	1085.44	1087.32	11.00	22.50	4.46	53.85	200.00	36.00	.00	1100.00	400.00	1100.00
*	6360.000	1085.91	1087.79	11.00	22.50	4.46	53.85	200.00	36.00	.00	1100.00	400.00	1100.00
*	6380.000	1086.37	1088.25	11.00	22.50	4.46	53.85	200.00	36.00	.00	1100.00	400.00	1100.00

	SECNO	CWSEL	EG	VCH	10*KS	DEPTH	TOPWID	CLSTA	BW	STCHL	XLBEL	STCHR	RBEL
*	6400.000	1086.84	1088.72	11.00	22.50	4.46	53.85	200.00	36.00	.00	1100.00	400.00	1100.00
*	6420.000	1087.31	1089.19	11.00	22.50	4.46	53.85	200.00	36.00	.00	1100.00	400.00	1100.00
*	6440.000	1087.77	1089.65	11.00	22.50	4.46	53.85	200.00	36.00	.00	1100.00	400.00	1100.00
	6460.000	1088.12	1089.72	10.15	17.78	4.78	55.08	200.00	36.00	.00	1100.00	400.00	1100.00
	6500.000	1088.31	1089.80	9.79	15.96	4.91	55.67	200.00	36.00	.00	1100.00	400.00	1100.00
	6540.000	1088.37	1089.86	9.80	16.03	4.91	55.65	200.00	36.00	.00	1100.00	400.00	1100.00
	6580.000	1088.44	1089.93	9.80	16.01	4.92	55.66	200.00	36.00	.00	1100.00	400.00	1100.00
	6621.000	1088.51	1089.99	9.78	15.94	4.93	55.68	200.00	36.00	.00	1100.00	400.00	1100.00
	6650.000	1089.18	1090.09	8.26	10.98	5.22	81.78	200.00	31.56	172.13	1090.01	229.33	1090.74
*	6700.000	1089.20	1090.84	11.30	25.32	4.58	74.21	200.00	23.92	177.70	1089.79	225.02	1091.15
*	6752.000	1090.24	1091.92	11.84	28.42	4.94	72.21	200.00	16.00	180.60	1091.00	220.22	1091.41
*	6800.000	1092.75	1093.92	9.56	32.14	6.75	185.70	.00	.01	120.00	1091.60	156.00	1091.20
*	6900.000	1093.56	1094.78	9.75	32.67	6.46	169.36	.00	.01	120.00	1092.60	155.00	1091.40
*	7000.000	1094.35	1095.57	9.69	32.21	6.25	168.22	.00	.01	119.00	1093.50	155.00	1091.70
*	7100.000	1094.83	1096.19	9.53	47.47	5.73	134.57	.00	.01	119.00	1094.50	179.00	1093.90
*	7200.000	1095.67	1097.05	9.57	48.35	5.57	126.69	.00	.01	119.00	1095.40	180.00	1095.00
*	7300.000	1096.54	1097.85	9.42	46.82	5.44	147.12	.00	.01	120.00	1096.00	181.00	1095.70
*	7400.000	1097.52	1098.62	8.83	40.17	5.52	171.32	.00	.01	121.00	1096.70	182.00	1096.40
*	7500.000	1098.34	1099.39	8.80	40.28	5.44	180.49	.00	.01	123.00	1097.30	182.00	1097.10

CHANNEL IMPROVE, SUBCRIT

SUMMARY PRINTOUT TABLE 150

	SECNO	XLCH	ELTRD	ELLC	ELMIN	Q	CWSEL	CRIWS	EG	10*KS	VCH	AREA	.01K
	1000.000	.00	.00	.00	1040.90	2206.00	1044.72	1044.35	1045.64	40.44	7.92	306.60	346.89
	1080.000	79.83	.00	.00	1041.20	2206.00	1045.06	1044.42	1045.95	35.72	7.57	291.51	369.09
	1116.000	36.42	.00	.00	1041.23	2206.00	1045.29	1044.44	1046.08	29.20	7.12	309.72	408.26
	1150.000	33.75	.00	.00	1041.26	2206.00	1045.55	1044.35	1046.17	21.32	6.35	347.32	477.72
	1200.000	50.00	.00	.00	1041.30	2206.00	1045.69	1044.41	1046.28	19.90	6.18	356.79	494.48
	1250.000	50.00	.00	.00	1041.34	2206.00	1045.85	1044.38	1046.38	16.92	5.81	379.42	536.25
	1300.000	50.00	.00	.00	1041.38	2206.00	1045.99	1044.37	1046.46	14.83	5.53	399.23	572.77
	1350.000	50.00	.00	.00	1041.42	2206.00	1046.10	1044.35	1046.54	13.25	5.29	417.34	606.05
	1400.000	50.00	.00	.00	1041.46	2206.00	1046.20	1044.34	1046.60	12.00	5.08	434.17	636.89
	1456.000	56.33	.00	.00	1041.50	2206.00	1046.30	1044.33	1046.67	10.87	4.88	451.85	669.14
	1495.000	38.67	.00	.00	1041.54	2206.00	1046.32	1044.40	1046.73	11.61	5.15	427.99	647.30
	1550.000	55.00	.00	.00	1041.58	2206.00	1046.20	1044.76	1046.84	6.61	6.43	343.29	857.99
*	1560.000	10.00	.00	.00	1044.83	2206.00	1048.01	1048.01	1049.48	23.78	9.74	226.60	452.42
*	1580.000	20.00	.00	.00	1044.85	2206.00	1048.50	1048.02	1049.58	51.67	8.36	263.85	306.90
	1600.000	20.00	.00	.00	1044.86	2206.00	1048.74	1048.04	1049.69	42.07	7.82	282.01	340.10
	1650.000	50.00	.00	.00	1044.90	2206.00	1048.92	1048.22	1049.91	42.41	7.99	276.17	338.75
	1700.000	50.00	.00	.00	1044.94	2206.00	1049.10	1048.41	1050.15	43.74	8.22	268.29	333.55
	1750.000	50.00	.00	.00	1044.98	2206.00	1049.27	1048.62	1050.39	45.89	8.52	259.00	325.63
	1800.000	50.00	.00	.00	1045.02	2206.00	1049.44	1048.85	1050.66	48.86	8.87	248.65	315.59
	1850.000	50.00	.00	.00	1045.06	2206.00	1049.61	1049.10	1050.95	52.87	9.30	237.27	303.40
	1900.000	50.00	.00	.00	1045.10	2206.00	1049.78	1049.41	1051.27	58.26	9.81	224.84	289.02
	1931.000	31.29	.00	.00	1045.13	2206.00	1049.88	1049.60	1051.50	62.77	10.20	216.29	278.44
*	1950.000	18.71	.00	.00	1045.16	2206.00	1050.10	1049.62	1051.56	15.65	9.72	226.99	557.71
	2000.000	50.00	.00	.00	1045.23	2206.00	1050.17	1049.69	1051.64	15.72	9.73	226.63	556.42

	SECNO	XLCH	ELTRD	ELLC	ELMIN	Q	CWSEL	CRIWS	EG	10*KS	VCH	AREA	.01K
	2050.000	50.00	.00	.00	1045.31	2206.00	1050.25	1049.77	1051.72	15.72	9.73	226.64	556.45
	2100.000	50.00	.00	.00	1045.38	2206.00	1050.33	1049.84	1051.80	15.67	9.72	226.85	557.20
	2150.000	50.00	.00	.00	1045.46	2206.00	1050.42	1049.92	1051.88	15.60	9.71	227.22	558.52
	2200.000	50.00	.00	.00	1045.53	2206.00	1050.50	1049.99	1051.96	15.51	9.69	227.68	560.18
	2250.000	50.00	.00	.00	1045.61	2206.00	1050.59	1050.07	1052.04	15.40	9.67	228.20	562.06
	2300.000	50.00	.00	.00	1045.68	2206.00	1050.67	1050.14	1052.11	15.30	9.64	228.75	564.03
	2350.000	50.00	.00	.00	1045.76	2206.00	1050.75	1050.22	1052.19	15.20	9.62	229.28	565.92
	2400.000	50.00	.00	.00	1045.83	2206.00	1050.84	1050.29	1052.27	15.10	9.60	229.75	567.64
	2450.000	50.00	.00	.00	1045.91	2206.00	1050.92	1050.37	1052.34	15.03	9.58	230.16	569.11
	2500.000	50.00	.00	.00	1045.98	2206.00	1051.00	1050.44	1052.42	14.96	9.57	230.50	570.32
	2550.000	50.00	.00	.00	1046.06	2206.00	1051.07	1050.52	1052.49	14.91	9.56	230.76	571.26
	2600.000	50.00	.00	.00	1046.13	2206.00	1051.15	1050.59	1052.57	14.88	9.55	230.94	571.90
	2650.000	50.00	.00	.00	1046.21	2206.00	1051.23	1050.67	1052.64	14.86	9.55	231.05	572.29
	2700.000	50.00	.00	.00	1046.28	2206.00	1051.30	1050.74	1052.72	14.85	9.55	231.09	572.47
	2750.000	50.00	.00	.00	1046.36	2206.00	1051.38	1050.82	1052.79	14.85	9.55	231.09	572.47
	2800.000	50.00	.00	.00	1046.43	2206.00	1051.45	1050.89	1052.87	14.86	9.55	231.05	572.32
	2850.000	50.00	.00	.00	1046.51	2206.00	1051.52	1050.97	1052.94	14.87	9.55	230.99	572.10
	2885.000	35.00	.00	.00	1046.56	2206.00	1051.58	1051.02	1052.99	14.88	9.55	230.93	571.87
*	2900.000	15.00	.00	.00	1051.56	2206.00	1056.02	1056.02	1057.90	22.55	11.01	200.35	464.59
*	2950.000	50.00	.00	.00	1051.81	2206.00	1056.27	1056.27	1058.15	22.50	11.00	200.49	465.09
*	3000.000	50.00	.00	.00	1052.06	2206.00	1056.52	1056.52	1058.40	22.50	11.00	200.49	465.09
*	3050.000	50.00	.00	.00	1052.31	2206.00	1056.77	1056.77	1058.65	22.50	11.00	200.49	465.09
*	3100.000	50.00	.00	.00	1052.56	2206.00	1057.02	1057.02	1058.90	22.50	11.00	200.49	465.09
*	3150.000	50.00	.00	.00	1052.81	2206.00	1057.27	1057.27	1059.15	22.50	11.00	200.49	465.09
*	3200.000	50.00	.00	.00	1053.06	2206.00	1057.52	1057.52	1059.40	22.50	11.00	200.49	465.09
*	3250.000	50.00	.00	.00	1053.31	2206.00	1057.77	1057.77	1059.65	22.50	11.00	200.49	465.09

	SECNO	XLCH	ELTRD	ELLC	ELMIN	Q	CWSEL	CRIWS	EG	10*KS	VCH	AREA	.01K
*	3300.000	50.00	.00	.00	1053.56	2206.00	1058.02	1058.02	1059.90	22.50	11.00	200.49	465.09
*	3350.000	50.00	.00	.00	1053.81	2206.00	1058.27	1058.27	1060.15	22.50	11.00	200.49	465.09
*	3400.000	50.00	.00	.00	1054.06	2206.00	1058.52	1058.52	1060.40	22.50	11.00	200.49	465.09
*	3450.000	50.00	.00	.00	1054.31	2206.00	1058.77	1058.77	1060.65	22.50	11.00	200.49	465.09
*	3500.000	50.00	.00	.00	1054.56	2206.00	1059.02	1059.02	1060.90	22.50	11.00	200.49	465.09
*	3550.000	50.00	.00	.00	1054.81	2206.00	1059.27	1059.27	1061.15	22.50	11.00	200.49	465.09
*	3600.000	50.00	.00	.00	1055.06	2206.00	1059.52	1059.52	1061.40	22.50	11.00	200.49	465.09
*	3650.000	50.00	.00	.00	1055.31	2206.00	1059.77	1059.77	1061.65	22.50	11.00	200.49	465.09
*	3700.000	50.00	.00	.00	1055.56	2206.00	1060.02	1060.02	1061.90	22.50	11.00	200.49	465.09
*	3720.000	20.00	.00	.00	1056.01	2206.00	1060.47	1060.47	1062.35	22.50	11.00	200.49	465.09
*	3740.000	20.00	.00	.00	1056.46	2206.00	1060.92	1060.92	1062.80	22.50	11.00	200.49	465.09
*	3760.000	20.00	.00	.00	1056.90	2206.00	1061.37	1061.37	1063.25	22.50	11.00	200.49	465.09
*	3780.000	20.00	.00	.00	1057.35	2206.00	1061.81	1061.81	1063.69	22.50	11.00	200.49	465.09
*	3800.000	20.00	.00	.00	1057.80	2206.00	1062.26	1062.26	1064.14	22.50	11.00	200.49	465.09
	3850.000	50.00	.00	.00	1057.87	2206.00	1062.76	1062.34	1064.27	16.40	9.88	223.36	544.74
	3900.000	50.00	.00	.00	1057.95	2206.00	1062.85	1062.41	1064.36	16.28	9.85	223.90	546.67
	3950.000	50.00	.00	.00	1058.02	2206.00	1062.99	1062.48	1064.44	15.44	9.67	228.05	561.50
	4008.000	58.23	.00	.00	1058.11	2206.00	1063.08	1062.57	1064.53	15.44	9.67	228.02	561.40
*	4050.000	41.77	.00	.00	1058.17	2206.00	1063.89	1062.16	1064.64	6.49	6.94	317.96	865.92
	4100.000	50.33	.00	.00	1058.25	2206.00	1064.20	1061.79	1064.69	3.88	5.61	393.34	1119.84
	4125.000	30.00	.00	.00	1058.29	2206.00	1064.31	1061.63	1064.71	3.10	5.09	433.37	1253.21
	4163.000	38.00	.00	.00	1058.35	2206.00	1064.32	1061.69	1064.73	3.19	5.14	429.12	1234.92
*	4175.000	12.00	.00	.00	1062.42	2206.00	1065.76	1065.76	1067.28	23.47	9.92	222.48	455.37
*	4190.000	15.00	.00	.00	1062.40	2206.00	1065.80	1065.80	1067.50	24.76	10.46	210.82	443.31
*	4197.000	11.00	.00	.00	1062.50	2206.00	1066.22	1066.22	1068.09	25.34	10.99	200.81	438.23
*	4248.000	51.00	1069.00	1066.70	1062.70	2206.00	1068.38	.00	1069.18	6.67	7.19	306.64	854.00

	SECNO	XLCH	ELTRD	ELLC	ELMIN	Q	CWSEL	CRIWS	EG	10*KS	VCH	AREA	.01K
	4300.000	52.00	.00	.00	1063.10	2206.00	1068.26	1067.28	1069.39	10.71	8.51	259.31	674.21
*	4350.000	50.00	.00	.00	1063.40	2206.00	1067.85	1067.85	1069.82	22.58	11.26	195.97	464.27
*	4400.000	50.00	.00	.00	1063.60	2206.00	1068.23	1068.23	1070.20	22.81	11.28	195.57	461.93
*	4450.000	50.00	.00	.00	1064.00	2206.00	1068.39	1068.39	1070.33	22.55	11.17	197.55	464.59
*	4500.000	50.00	.00	.00	1064.20	2206.00	1068.60	1068.60	1070.59	22.97	11.33	194.72	460.28
*	4550.000	50.00	.00	.00	1064.50	2206.00	1068.86	1068.86	1070.86	23.07	11.37	194.10	459.31
	4600.000	50.00	.00	.00	1064.70	2206.00	1069.73	1068.92	1071.02	12.44	9.12	242.05	625.38
	4645.000	45.00	.00	.00	1065.50	2206.00	1070.14	1069.43	1071.16	12.30	8.09	272.52	629.13
	4660.000	15.00	.00	.00	1065.00	2206.00	1070.25	1068.71	1071.19	8.60	7.79	283.11	752.15
	4712.000	52.00	1073.00	1070.30	1065.30	2206.00	1071.51	.00	1072.19	5.08	6.58	335.48	978.54
	4733.000	21.00	.00	.00	1065.40	2206.00	1071.76	1069.20	1072.25	3.34	5.86	482.23	1207.50
*	4738.000	5.00	.00	.00	1067.42	2206.00	1071.22	1071.15	1072.79	21.29	10.07	219.06	478.04
	4750.000	12.00	.00	.00	1067.44	2206.00	1071.24	1071.16	1072.82	21.34	10.08	218.89	477.49
	4800.000	50.00	.00	.00	1067.51	2206.00	1071.60	1071.23	1072.94	16.61	9.28	237.78	541.24
	4850.000	50.00	.00	.00	1067.59	2206.00	1071.73	1071.30	1073.02	15.84	9.13	241.54	554.20
	4900.000	50.00	.00	.00	1067.66	2206.00	1071.81	1071.37	1073.10	15.86	9.14	241.47	553.95
	4950.000	50.00	.00	.00	1067.73	2206.00	1071.89	1071.45	1073.18	15.80	9.12	241.78	555.01
	5000.000	50.00	.00	.00	1067.81	2206.00	1072.01	1071.52	1073.26	15.11	8.99	245.35	567.44
	5050.000	50.00	.00	.00	1067.88	2206.00	1072.08	1071.60	1073.34	15.12	8.99	245.30	567.26
	5100.000	50.00	.00	.00	1067.96	2206.00	1072.16	1071.67	1073.42	15.11	8.99	245.37	567.52
	5120.000	20.00	.00	.00	1067.99	2206.00	1071.87	1071.79	1073.59	22.65	10.54	209.22	463.50
	5170.000	50.00	.00	.00	1068.06	2206.00	1072.28	1071.86	1073.72	17.09	9.62	229.29	533.64
*	5180.000	18.00	.00	.00	1071.56	2206.00	1075.37	1075.37	1077.17	24.14	10.76	204.96	449.02
*	5200.000	20.00	.00	.00	1071.70	2206.00	1075.51	1075.51	1077.31	24.06	10.75	205.17	449.76
*	5235.000	35.00	.00	.00	1072.00	2206.00	1075.87	1075.87	1077.81	25.27	11.18	197.39	438.81
*	5323.000	88.00	1080.00	1077.40	1072.90	2206.00	1078.00	.00	1079.12	10.67	8.49	259.91	675.45

	SECNO	XLCH	ELTRD	ELLC	ELMIN	Q	CWSEL	CRIWS	EG	10*KS	VCH	AREA	.01K
	5325.000	2.00	.00	.00	1072.94	2206.00	1078.37	1076.75	1079.20	7.48	7.33	300.83	806.62
	5350.000	25.00	.00	.00	1072.98	2206.00	1078.28	1076.95	1079.27	9.22	7.98	276.37	726.35
	5400.000	50.00	.00	.00	1073.05	2206.00	1078.27	1077.24	1079.34	10.52	8.31	265.32	680.21
	5434.000	34.27	.00	.00	1073.10	2206.00	1078.04	1077.57	1079.51	15.70	9.73	226.74	556.81
	5450.000	15.73	.00	.00	1073.13	2206.00	1078.06	1077.59	1079.53	15.78	9.75	226.32	555.30
	5500.000	50.00	.00	.00	1073.20	2206.00	1078.14	1077.66	1079.61	15.81	9.75	226.17	554.77
	5544.000	43.53	.00	.00	1073.27	2206.00	1078.21	1077.73	1079.68	15.78	9.75	226.33	555.35
	5600.000	63.36	.00	.00	1073.36	2206.00	1078.32	1077.82	1079.78	15.65	9.72	226.95	557.57
	5650.000	50.00	.00	.00	1073.44	2206.00	1078.40	1077.89	1079.86	15.50	9.69	227.72	560.33
	5700.000	50.00	.00	.00	1073.51	2206.00	1078.49	1077.97	1079.94	15.40	9.67	228.22	562.14
	5750.000	50.00	.00	.00	1073.59	2206.00	1078.57	1078.04	1080.02	15.30	9.64	228.76	564.05
	5800.000	50.00	.00	.00	1073.66	2206.00	1078.66	1078.12	1080.09	15.19	9.62	229.28	565.94
	5850.000	50.00	.00	.00	1073.73	2206.00	1078.74	1078.19	1080.17	15.10	9.60	229.78	567.73
	5885.000	35.00	.00	.00	1073.79	2206.00	1078.80	1078.25	1080.22	15.01	9.58	230.22	569.31
*	5900.000	15.00	.00	.00	1078.78	2206.00	1083.24	1083.24	1085.12	22.56	11.01	200.30	464.41
*	5950.000	50.00	.00	.00	1079.03	2206.00	1083.49	1083.49	1085.37	22.47	11.00	200.56	465.33
*	6000.000	50.00	.00	.00	1079.28	2206.00	1083.74	1083.74	1085.62	22.48	11.00	200.54	465.24
*	6050.000	50.00	.00	.00	1079.53	2206.00	1083.99	1083.99	1085.87	22.50	11.00	200.49	465.09
*	6100.000	50.00	.00	.00	1079.78	2206.00	1084.24	1084.24	1086.12	22.50	11.00	200.49	465.09
*	6150.000	50.00	.00	.00	1080.03	2206.00	1084.49	1084.49	1086.37	22.50	11.00	200.49	465.09
*	6200.000	50.00	.00	.00	1080.28	2206.00	1084.74	1084.74	1086.62	22.50	11.00	200.49	465.09
*	6250.000	50.00	.00	.00	1080.53	2206.00	1084.99	1084.99	1086.87	22.50	11.00	200.49	465.09
*	6300.000	50.00	.00	.00	1080.78	2206.00	1085.24	1085.24	1087.12	22.50	11.00	200.49	465.09
*	6340.000	40.00	.00	.00	1080.98	2206.00	1085.44	1085.44	1087.32	22.50	11.00	200.49	465.09
*	6360.000	20.00	.00	.00	1081.45	2206.00	1085.91	1085.91	1087.79	22.50	11.00	200.49	465.09
*	6380.000	20.00	.00	.00	1081.91	2206.00	1086.37	1086.37	1088.25	22.50	11.00	200.49	465.09

	SECNO	XLCH	ELTRD	ELLC	ELMIN	Q	CWSEL	CRIWS	EG	10*KS	VCH	AREA	.01K
*	6400.000	20.00	.00	.00	1082.38	2206.00	1086.84	1086.84	1088.72	22.50	11.00	200.49	465.09
*	6420.000	20.00	.00	.00	1082.84	2206.00	1087.31	1087.31	1089.19	22.50	11.00	200.49	465.09
*	6440.000	20.00	.00	.00	1083.31	2206.00	1087.77	1087.77	1089.65	22.50	11.00	200.49	465.09
	6460.000	20.00	.00	.00	1083.34	2206.00	1088.12	1087.80	1089.72	17.78	10.15	217.26	523.16
	6500.000	40.00	.00	.00	1083.40	2206.00	1088.31	1087.86	1089.80	15.96	9.79	225.43	552.14
	6540.000	40.00	.00	.00	1083.46	2206.00	1088.37	1087.92	1089.86	16.03	9.80	225.13	551.05
	6580.000	40.00	.00	.00	1083.52	2206.00	1088.44	1087.98	1089.93	16.01	9.80	225.21	551.34
	6621.000	40.93	.00	.00	1083.58	2206.00	1088.51	1088.04	1089.99	15.94	9.78	225.52	552.46
	6650.000	29.07	.00	.00	1083.96	2206.00	1089.18	1088.14	1090.09	10.98	8.26	318.43	665.79
*	6700.000	50.00	.00	.00	1084.62	2206.00	1089.20	1089.20	1090.84	25.32	11.30	240.11	438.36
*	6752.000	51.83	.00	.00	1085.30	2206.00	1090.24	1090.24	1091.92	28.42	11.84	237.48	413.78
*	6800.000	63.99	.00	.00	1086.00	2206.00	1092.75	1092.75	1093.92	32.14	9.56	346.11	389.09
*	6900.000	100.00	.00	.00	1087.10	2206.00	1093.56	1093.56	1094.78	32.67	9.75	338.45	385.96
*	7000.000	100.00	.00	.00	1088.10	2206.00	1094.35	1094.35	1095.57	32.21	9.69	329.43	388.72
*	7100.000	100.00	.00	.00	1089.10	2206.00	1094.83	1094.83	1096.19	47.47	9.53	265.40	320.17
*	7200.000	100.00	.00	.00	1090.10	2206.00	1095.67	1095.67	1097.05	48.35	9.57	255.88	317.25
*	7300.000	100.00	.00	.00	1091.10	2206.00	1096.54	1096.54	1097.85	46.82	9.42	274.07	322.39
*	7400.000	100.00	.00	.00	1092.00	2206.00	1097.52	1097.52	1098.62	40.17	8.83	320.11	348.04
*	7500.000	100.00	.00	.00	1092.90	2206.00	1098.34	1098.34	1099.39	40.28	8.80	336.81	347.57

CHANNEL IMPROVE, SUBCRIT

SUMMARY PRINTOUT TABLE 150

	SECNO	Q	CWSEL	DIFWSP	DIFWSX	DIFKWS	TOPWID	XLCH
	1000.000	2206.00	1044.72	.00	.00	.00	119.56	.00
	1080.000	2206.00	1045.06	.00	.34	.00	92.56	79.83
	1116.000	2206.00	1045.29	.00	.23	.00	92.50	36.42
	1150.000	2206.00	1045.55	.00	.26	.00	96.94	33.75
	1200.000	2206.00	1045.69	.00	.14	.00	98.82	50.00
	1250.000	2206.00	1045.85	.00	.17	.00	102.05	50.00
	1300.000	2206.00	1045.99	.00	.14	.00	105.00	50.00
	1350.000	2206.00	1046.10	.00	.11	.00	107.80	50.00
	1400.000	2206.00	1046.20	.00	.10	.00	110.48	50.00
	1456.000	2206.00	1046.30	.00	.10	.00	113.38	56.33
	1495.000	2206.00	1046.32	.00	.01	.00	103.73	38.67
	1550.000	2206.00	1046.20	.00	-.11	.00	83.49	55.00
*	1560.000	2206.00	1048.01	.00	1.80	.00	77.70	10.00
*	1580.000	2206.00	1048.50	.00	.49	.00	79.60	20.00
	1600.000	2206.00	1048.74	.00	.24	.00	80.51	20.00
	1650.000	2206.00	1048.92	.00	.18	.00	76.71	50.00
	1700.000	2206.00	1049.10	.00	.17	.00	72.87	50.00
	1750.000	2206.00	1049.27	.00	.17	.00	69.01	50.00
	1800.000	2206.00	1049.44	.00	.17	.00	65.15	50.00
	1850.000	2206.00	1049.61	.00	.17	.00	61.30	50.00
	1900.000	2206.00	1049.78	.00	.17	.00	57.44	50.00
	1931.000	2206.00	1049.88	.00	.10	.00	55.01	31.29
*	1950.000	2206.00	1050.10	.00	.22	.00	55.78	18.71
	2000.000	2206.00	1050.17	.00	.08	.00	55.76	50.00

	SECNO	Q	CWSEL	DIFWSP	DIFWSX	DIFKWS	TOPWID	XLCH
	2050.000	2206.00	1050.25	.00	.08	.00	55.76	50.00
	2100.000	2206.00	1050.33	.00	.08	.00	55.77	50.00
	2150.000	2206.00	1050.42	.00	.08	.00	55.80	50.00
	2200.000	2206.00	1050.50	.00	.08	.00	55.83	50.00
	2250.000	2206.00	1050.59	.00	.08	.00	55.87	50.00
	2300.000	2206.00	1050.67	.00	.08	.00	55.91	50.00
	2350.000	2206.00	1050.75	.00	.08	.00	55.95	50.00
	2400.000	2206.00	1050.84	.00	.08	.00	55.98	50.00
	2450.000	2206.00	1050.92	.00	.08	.00	56.01	50.00
	2500.000	2206.00	1051.00	.00	.08	.00	56.04	50.00
	2550.000	2206.00	1051.07	.00	.08	.00	56.05	50.00
	2600.000	2206.00	1051.15	.00	.08	.00	56.07	50.00
	2650.000	2206.00	1051.23	.00	.08	.00	56.07	50.00
	2700.000	2206.00	1051.30	.00	.07	.00	56.08	50.00
	2750.000	2206.00	1051.38	.00	.07	.00	56.08	50.00
	2800.000	2206.00	1051.45	.00	.07	.00	56.08	50.00
	2850.000	2206.00	1051.52	.00	.07	.00	56.07	50.00
	2885.000	2206.00	1051.58	.00	.05	.00	56.07	35.00
*	2900.000	2206.00	1056.02	.00	4.44	.00	53.84	15.00
*	2950.000	2206.00	1056.27	.00	.25	.00	53.85	50.00
*	3000.000	2206.00	1056.52	.00	.25	.00	53.85	50.00
*	3050.000	2206.00	1056.77	.00	.25	.00	53.85	50.00
*	3100.000	2206.00	1057.02	.00	.25	.00	53.85	50.00
*	3150.000	2206.00	1057.27	.00	.25	.00	53.85	50.00
*	3200.000	2206.00	1057.52	.00	.25	.00	53.85	50.00
*	3250.000	2206.00	1057.77	.00	.25	.00	53.85	50.00

	SECNO	Q	CWSEL	DIFWSP	DIFWSX	DIFKWS	TOPWID	XLCH
*	3300.000	2206.00	1058.02	.00	.25	.00	53.85	50.00
*	3350.000	2206.00	1058.27	.00	.25	.00	53.85	50.00
*	3400.000	2206.00	1058.52	.00	.25	.00	53.85	50.00
*	3450.000	2206.00	1058.77	.00	.25	.00	53.85	50.00
*	3500.000	2206.00	1059.02	.00	.25	.00	53.85	50.00
*	3550.000	2206.00	1059.27	.00	.25	.00	53.85	50.00
*	3600.000	2206.00	1059.52	.00	.25	.00	53.85	50.00
*	3650.000	2206.00	1059.77	.00	.25	.00	53.85	50.00
*	3700.000	2206.00	1060.02	.00	.25	.00	53.85	50.00
*	3720.000	2206.00	1060.47	.00	.45	.00	53.85	20.00
*	3740.000	2206.00	1060.92	.00	.45	.00	53.85	20.00
*	3760.000	2206.00	1061.37	.00	.45	.00	53.85	20.00
*	3780.000	2206.00	1061.81	.00	.45	.00	53.85	20.00
*	3800.000	2206.00	1062.26	.00	.45	.00	53.85	20.00
	3850.000	2206.00	1062.76	.00	.50	.00	55.52	50.00
	3900.000	2206.00	1062.85	.00	.09	.00	55.56	50.00
	3950.000	2206.00	1062.99	.00	.14	.00	55.86	50.00
	4008.000	2206.00	1063.08	.00	.09	.00	55.86	58.23
*	4050.000	2206.00	1063.89	.00	.82	.00	67.07	41.77
	4100.000	2206.00	1064.20	.00	.31	.00	77.93	50.33
	4125.000	2206.00	1064.31	.00	.10	.00	84.07	30.00
	4163.000	2206.00	1064.32	.00	.01	.00	83.86	38.00
*	4175.000	2206.00	1065.76	.00	1.44	.00	73.35	12.00
*	4190.000	2206.00	1065.80	.00	.04	.00	62.00	15.00
*	4197.000	2206.00	1066.22	.00	.42	.00	53.99	11.00
*	4248.000	2206.00	1068.38	.00	2.16	.00	54.00	51.00

	SECNO	Q	CWSEL	DIFWSP	DIFWSX	DIFKWS	TOPWID	XLCH
	4300.000	2206.00	1068.26	.00	-.12	.00	59.99	52.00
*	4350.000	2206.00	1067.85	.00	-.41	.00	50.05	50.00
*	4400.000	2206.00	1068.23	.00	.38	.00	50.11	50.00
*	4450.000	2206.00	1068.39	.00	.17	.00	50.96	50.00
*	4500.000	2206.00	1068.60	.00	.21	.00	49.22	50.00
*	4550.000	2206.00	1068.86	.00	.26	.00	49.07	50.00
	4600.000	2206.00	1069.73	.00	.87	.00	54.68	50.00
	4645.000	2206.00	1070.14	.00	.41	.00	74.23	45.00
	4660.000	2206.00	1070.25	.00	.11	.00	53.99	15.00
	4712.000	2206.00	1071.51	.00	1.26	.00	54.00	52.00
	4733.000	2206.00	1071.76	.00	.25	.00	125.90	21.00
*	4738.000	2206.00	1071.22	.00	-.54	.00	65.21	5.00
	4750.000	2206.00	1071.24	.00	.02	.00	65.20	12.00
	4800.000	2206.00	1071.60	.00	.36	.00	66.35	50.00
	4850.000	2206.00	1071.73	.00	.13	.00	66.58	50.00
	4900.000	2206.00	1071.81	.00	.08	.00	66.57	50.00
	4950.000	2206.00	1071.89	.00	.08	.00	66.59	50.00
	5000.000	2206.00	1072.01	.00	.12	.00	66.80	50.00
	5050.000	2206.00	1072.08	.00	.08	.00	66.80	50.00
	5100.000	2206.00	1072.16	.00	.08	.00	66.81	50.00
	5120.000	2206.00	1071.87	.00	-.29	.00	57.77	20.00
	5170.000	2206.00	1072.28	.00	.42	.00	58.46	50.00
*	5180.000	2206.00	1075.37	.00	3.09	.00	57.62	18.00
*	5200.000	2206.00	1075.51	.00	.14	.00	57.63	20.00
*	5235.000	2206.00	1075.87	.00	.36	.00	50.99	35.00
*	5323.000	2206.00	1078.00	.00	2.13	.00	50.99	88.00

	SECNO	Q	CWSEL	DIFWSP	DIFWSX	DIFKWS	TOPWID	XLCH
	5325.000	2206.00	1078.37	.00	.37	.00	60.86	2.00
	5350.000	2206.00	1078.28	.00	-.09	.00	57.41	25.00
	5400.000	2206.00	1078.27	.00	-.01	.00	61.27	50.00
	5434.000	2206.00	1078.04	.00	-.23	.00	55.77	34.27
	5450.000	2206.00	1078.06	.00	.02	.00	55.74	15.73
	5500.000	2206.00	1078.14	.00	.08	.00	55.73	50.00
	5544.000	2206.00	1078.21	.00	.07	.00	55.74	43.53
	5600.000	2206.00	1078.32	.00	.11	.00	55.78	63.36
	5650.000	2206.00	1078.40	.00	.09	.00	55.84	50.00
	5700.000	2206.00	1078.49	.00	.08	.00	55.87	50.00
	5750.000	2206.00	1078.57	.00	.08	.00	55.91	50.00
	5800.000	2206.00	1078.66	.00	.08	.00	55.95	50.00
	5850.000	2206.00	1078.74	.00	.08	.00	55.98	50.00
	5885.000	2206.00	1078.80	.00	.06	.00	56.02	35.00
*	5900.000	2206.00	1083.24	.00	4.44	.00	53.84	15.00
*	5950.000	2206.00	1083.49	.00	.26	.00	53.86	50.00
*	6000.000	2206.00	1083.74	.00	.25	.00	53.85	50.00
*	6050.000	2206.00	1083.99	.00	.25	.00	53.85	50.00
*	6100.000	2206.00	1084.24	.00	.25	.00	53.85	50.00
*	6150.000	2206.00	1084.49	.00	.25	.00	53.85	50.00
*	6200.000	2206.00	1084.74	.00	.25	.00	53.85	50.00
*	6250.000	2206.00	1084.99	.00	.25	.00	53.85	50.00
*	6300.000	2206.00	1085.24	.00	.25	.00	53.85	50.00
*	6340.000	2206.00	1085.44	.00	.20	.00	53.85	40.00
*	6360.000	2206.00	1085.91	.00	.47	.00	53.85	20.00
*	6380.000	2206.00	1086.37	.00	.47	.00	53.85	20.00

	SECNO	Q	CWSEL	DIFWSP	DIFWSX	DIFKWS	TOPWID	XLCH
*	6400.000	2206.00	1086.84	.00	.47	.00	53.85	20.00
*	6420.000	2206.00	1087.31	.00	.47	.00	53.85	20.00
*	6440.000	2206.00	1087.77	.00	.47	.00	53.85	20.00
	6460.000	2206.00	1088.12	.00	.35	.00	55.08	20.00
	6500.000	2206.00	1088.31	.00	.19	.00	55.67	40.00
	6540.000	2206.00	1088.37	.00	.06	.00	55.65	40.00
	6580.000	2206.00	1088.44	.00	.07	.00	55.66	40.00
	6621.000	2206.00	1088.51	.00	.07	.00	55.68	40.93
	6650.000	2206.00	1089.18	.00	.67	.00	81.78	29.07
*	6700.000	2206.00	1089.20	.00	.02	.00	74.21	50.00
*	6752.000	2206.00	1090.24	.00	1.04	.00	72.21	51.83
*	6800.000	2206.00	1092.75	.00	2.52	.00	185.70	63.99
*	6900.000	2206.00	1093.56	.00	.81	.00	169.36	100.00
*	7000.000	2206.00	1094.35	.00	.79	.00	168.22	100.00
*	7100.000	2206.00	1094.83	.00	.48	.00	134.57	100.00
*	7200.000	2206.00	1095.67	.00	.83	.00	126.69	100.00
*	7300.000	2206.00	1096.54	.00	.87	.00	147.12	100.00
*	7400.000	2206.00	1097.52	.00	.98	.00	171.32	100.00
*	7500.000	2206.00	1098.34	.00	.82	.00	180.49	100.00

SUMMARY OF ERRORS AND SPECIAL NOTES

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CAUTION SECNO=   1560.000  PROFILE=  1  CRITICAL DEPTH ASSUMED
CAUTION SECNO=   1560.000  PROFILE=  1  MINIMUM SPECIFIC ENERGY

WARNING SECNO=   1580.000  PROFILE=  1  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE

WARNING SECNO=   1950.000  PROFILE=  1  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE

CAUTION SECNO=   2900.000  PROFILE=  1  CRITICAL DEPTH ASSUMED
CAUTION SECNO=   2900.000  PROFILE=  1  MINIMUM SPECIFIC ENERGY

CAUTION SECNO=   2950.000  PROFILE=  1  CRITICAL DEPTH ASSUMED
CAUTION SECNO=   2950.000  PROFILE=  1  MINIMUM SPECIFIC ENERGY

CAUTION SECNO=   3000.000  PROFILE=  1  CRITICAL DEPTH ASSUMED
CAUTION SECNO=   3000.000  PROFILE=  1  MINIMUM SPECIFIC ENERGY

CAUTION SECNO=   3050.000  PROFILE=  1  CRITICAL DEPTH ASSUMED
CAUTION SECNO=   3050.000  PROFILE=  1  MINIMUM SPECIFIC ENERGY

CAUTION SECNO=   3100.000  PROFILE=  1  CRITICAL DEPTH ASSUMED
CAUTION SECNO=   3100.000  PROFILE=  1  MINIMUM SPECIFIC ENERGY

CAUTION SECNO=   3150.000  PROFILE=  1  CRITICAL DEPTH ASSUMED
CAUTION SECNO=   3150.000  PROFILE=  1  MINIMUM SPECIFIC ENERGY

CAUTION SECNO=   3200.000  PROFILE=  1  CRITICAL DEPTH ASSUMED
CAUTION SECNO=   3200.000  PROFILE=  1  MINIMUM SPECIFIC ENERGY

CAUTION SECNO=   3250.000  PROFILE=  1  CRITICAL DEPTH ASSUMED
CAUTION SECNO=   3250.000  PROFILE=  1  MINIMUM SPECIFIC ENERGY

CAUTION SECNO=   3300.000  PROFILE=  1  CRITICAL DEPTH ASSUMED
CAUTION SECNO=   3300.000  PROFILE=  1  MINIMUM SPECIFIC ENERGY

CAUTION SECNO=   3350.000  PROFILE=  1  CRITICAL DEPTH ASSUMED
CAUTION SECNO=   3350.000  PROFILE=  1  MINIMUM SPECIFIC ENERGY

CAUTION SECNO=   3400.000  PROFILE=  1  CRITICAL DEPTH ASSUMED
CAUTION SECNO=   3400.000  PROFILE=  1  MINIMUM SPECIFIC ENERGY

CAUTION SECNO=   3450.000  PROFILE=  1  CRITICAL DEPTH ASSUMED
CAUTION SECNO=   3450.000  PROFILE=  1  MINIMUM SPECIFIC ENERGY

CAUTION SECNO=   3500.000  PROFILE=  1  CRITICAL DEPTH ASSUMED
CAUTION SECNO=   3500.000  PROFILE=  1  MINIMUM SPECIFIC ENERGY

CAUTION SECNO=   3550.000  PROFILE=  1  CRITICAL DEPTH ASSUMED
CAUTION SECNO=   3550.000  PROFILE=  1  MINIMUM SPECIFIC ENERGY

CAUTION SECNO=   3600.000  PROFILE=  1  CRITICAL DEPTH ASSUMED
CAUTION SECNO=   3600.000  PROFILE=  1  MINIMUM SPECIFIC ENERGY
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CAUTION SECNO=   3650.000  PROFILE=  1  CRITICAL DEPTH ASSUMED
CAUTION SECNO=   3650.000  PROFILE=  1  MINIMUM SPECIFIC ENERGY

CAUTION SECNO=   3700.000  PROFILE=  1  CRITICAL DEPTH ASSUMED
CAUTION SECNO=   3700.000  PROFILE=  1  MINIMUM SPECIFIC ENERGY

CAUTION SECNO=   3720.000  PROFILE=  1  CRITICAL DEPTH ASSUMED
CAUTION SECNO=   3720.000  PROFILE=  1  MINIMUM SPECIFIC ENERGY

CAUTION SECNO=   3740.000  PROFILE=  1  CRITICAL DEPTH ASSUMED
CAUTION SECNO=   3740.000  PROFILE=  1  MINIMUM SPECIFIC ENERGY

CAUTION SECNO=   3760.000  PROFILE=  1  CRITICAL DEPTH ASSUMED
CAUTION SECNO=   3760.000  PROFILE=  1  MINIMUM SPECIFIC ENERGY

CAUTION SECNO=   3780.000  PROFILE=  1  CRITICAL DEPTH ASSUMED
CAUTION SECNO=   3780.000  PROFILE=  1  MINIMUM SPECIFIC ENERGY

CAUTION SECNO=   3800.000  PROFILE=  1  CRITICAL DEPTH ASSUMED
CAUTION SECNO=   3800.000  PROFILE=  1  MINIMUM SPECIFIC ENERGY

WARNING SECNO=   4050.000  PROFILE=  1  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE

CAUTION SECNO=   4175.000  PROFILE=  1  CRITICAL DEPTH ASSUMED
CAUTION SECNO=   4175.000  PROFILE=  1  MINIMUM SPECIFIC ENERGY

CAUTION SECNO=   4190.000  PROFILE=  1  CRITICAL DEPTH ASSUMED
CAUTION SECNO=   4190.000  PROFILE=  1  MINIMUM SPECIFIC ENERGY

CAUTION SECNO=   4197.000  PROFILE=  1  CRITICAL DEPTH ASSUMED
CAUTION SECNO=   4197.000  PROFILE=  1  MINIMUM SPECIFIC ENERGY

CAUTION SECNO=   4248.000  PROFILE=  1  HYDRAULIC JUMP D.S.
WARNING SECNO=   4248.000  PROFILE=  1  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE

CAUTION SECNO=   4350.000  PROFILE=  1  CRITICAL DEPTH ASSUMED
CAUTION SECNO=   4350.000  PROFILE=  1  MINIMUM SPECIFIC ENERGY

CAUTION SECNO=   4400.000  PROFILE=  1  CRITICAL DEPTH ASSUMED
CAUTION SECNO=   4400.000  PROFILE=  1  MINIMUM SPECIFIC ENERGY

CAUTION SECNO=   4450.000  PROFILE=  1  CRITICAL DEPTH ASSUMED
CAUTION SECNO=   4450.000  PROFILE=  1  MINIMUM SPECIFIC ENERGY

CAUTION SECNO=   4500.000  PROFILE=  1  CRITICAL DEPTH ASSUMED
CAUTION SECNO=   4500.000  PROFILE=  1  MINIMUM SPECIFIC ENERGY

CAUTION SECNO=   4550.000  PROFILE=  1  CRITICAL DEPTH ASSUMED
CAUTION SECNO=   4550.000  PROFILE=  1  MINIMUM SPECIFIC ENERGY

WARNING SECNO=   4738.000  PROFILE=  1  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE

CAUTION SECNO=   5180.000  PROFILE=  1  CRITICAL DEPTH ASSUMED
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CAUTION SECNO=   5180.000  PROFILE=  1  MINIMUM SPECIFIC ENERGY

CAUTION SECNO=   5200.000  PROFILE=  1  CRITICAL DEPTH ASSUMED
CAUTION SECNO=   5200.000  PROFILE=  1  MINIMUM SPECIFIC ENERGY

CAUTION SECNO=   5235.000  PROFILE=  1  CRITICAL DEPTH ASSUMED
CAUTION SECNO=   5235.000  PROFILE=  1  MINIMUM SPECIFIC ENERGY

CAUTION SECNO=   5323.000  PROFILE=  1  HYDRAULIC JUMP D.S.
WARNING SECNO=   5323.000  PROFILE=  1  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE

CAUTION SECNO=   5900.000  PROFILE=  1  CRITICAL DEPTH ASSUMED
CAUTION SECNO=   5900.000  PROFILE=  1  MINIMUM SPECIFIC ENERGY

CAUTION SECNO=   5950.000  PROFILE=  1  CRITICAL DEPTH ASSUMED
CAUTION SECNO=   5950.000  PROFILE=  1  MINIMUM SPECIFIC ENERGY

CAUTION SECNO=   6000.000  PROFILE=  1  CRITICAL DEPTH ASSUMED
CAUTION SECNO=   6000.000  PROFILE=  1  MINIMUM SPECIFIC ENERGY

CAUTION SECNO=   6050.000  PROFILE=  1  CRITICAL DEPTH ASSUMED
CAUTION SECNO=   6050.000  PROFILE=  1  MINIMUM SPECIFIC ENERGY

CAUTION SECNO=   6100.000  PROFILE=  1  CRITICAL DEPTH ASSUMED
CAUTION SECNO=   6100.000  PROFILE=  1  MINIMUM SPECIFIC ENERGY

CAUTION SECNO=   6150.000  PROFILE=  1  CRITICAL DEPTH ASSUMED
CAUTION SECNO=   6150.000  PROFILE=  1  MINIMUM SPECIFIC ENERGY

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CAUTION SECNO=   6200.000  PROFILE=  1  MINIMUM SPECIFIC ENERGY

CAUTION SECNO=   6250.000  PROFILE=  1  CRITICAL DEPTH ASSUMED
CAUTION SECNO=   6250.000  PROFILE=  1  MINIMUM SPECIFIC ENERGY

CAUTION SECNO=   6300.000  PROFILE=  1  CRITICAL DEPTH ASSUMED
CAUTION SECNO=   6300.000  PROFILE=  1  MINIMUM SPECIFIC ENERGY

CAUTION SECNO=   6340.000  PROFILE=  1  CRITICAL DEPTH ASSUMED
CAUTION SECNO=   6340.000  PROFILE=  1  MINIMUM SPECIFIC ENERGY

CAUTION SECNO=   6360.000  PROFILE=  1  CRITICAL DEPTH ASSUMED
CAUTION SECNO=   6360.000  PROFILE=  1  MINIMUM SPECIFIC ENERGY

CAUTION SECNO=   6380.000  PROFILE=  1  CRITICAL DEPTH ASSUMED
CAUTION SECNO=   6380.000  PROFILE=  1  MINIMUM SPECIFIC ENERGY

CAUTION SECNO=   6400.000  PROFILE=  1  CRITICAL DEPTH ASSUMED
CAUTION SECNO=   6400.000  PROFILE=  1  MINIMUM SPECIFIC ENERGY

CAUTION SECNO=   6420.000  PROFILE=  1  CRITICAL DEPTH ASSUMED
CAUTION SECNO=   6420.000  PROFILE=  1  MINIMUM SPECIFIC ENERGY

CAUTION SECNO=   6440.000  PROFILE=  1  CRITICAL DEPTH ASSUMED
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CAUTION SECNO=   6440.000  PROFILE=  1  MINIMUM SPECIFIC ENERGY

CAUTION SECNO=   6700.000  PROFILE=  1  CRITICAL DEPTH ASSUMED
CAUTION SECNO=   6700.000  PROFILE=  1  MINIMUM SPECIFIC ENERGY

CAUTION SECNO=   6752.000  PROFILE=  1  CRITICAL DEPTH ASSUMED
CAUTION SECNO=   6752.000  PROFILE=  1  MINIMUM SPECIFIC ENERGY

CAUTION SECNO=   6800.000  PROFILE=  1  CRITICAL DEPTH ASSUMED
CAUTION SECNO=   6800.000  PROFILE=  1  MINIMUM SPECIFIC ENERGY

CAUTION SECNO=   6900.000  PROFILE=  1  CRITICAL DEPTH ASSUMED
CAUTION SECNO=   6900.000  PROFILE=  1  MINIMUM SPECIFIC ENERGY

CAUTION SECNO=   7000.000  PROFILE=  1  CRITICAL DEPTH ASSUMED
CAUTION SECNO=   7000.000  PROFILE=  1  MINIMUM SPECIFIC ENERGY

CAUTION SECNO=   7100.000  PROFILE=  1  CRITICAL DEPTH ASSUMED
CAUTION SECNO=   7100.000  PROFILE=  1  MINIMUM SPECIFIC ENERGY

CAUTION SECNO=   7200.000  PROFILE=  1  CRITICAL DEPTH ASSUMED
CAUTION SECNO=   7200.000  PROFILE=  1  MINIMUM SPECIFIC ENERGY

CAUTION SECNO=   7300.000  PROFILE=  1  CRITICAL DEPTH ASSUMED
CAUTION SECNO=   7300.000  PROFILE=  1  MINIMUM SPECIFIC ENERGY

CAUTION SECNO=   7400.000  PROFILE=  1  CRITICAL DEPTH ASSUMED
CAUTION SECNO=   7400.000  PROFILE=  1  MINIMUM SPECIFIC ENERGY

CAUTION SECNO=   7500.000  PROFILE=  1  CRITICAL DEPTH ASSUMED
CAUTION SECNO=   7500.000  PROFILE=  1  MINIMUM SPECIFIC ENERGY
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THE FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

FINAL ESTIMATE AND QUANTITY CALCULATIONS

DIBBLE AND ASSOCIATES CONSULTING ENGINEERS

FLOOD CONTROL DISTRICT OF MARICOPA COUNTY	WHITE TANKS FRS #4 INLET CHANNEL IMPROVEMENTS Contract No. 92-38

ENGINEER'S ESTIMATE

PAY ITEM NO.	DESCRIPTION	APPROX. QUANTITY & UNIT	UNIT PRICE	AMOUNT
107-1	NPDES Permit Requirements	1 L.S.	$10,000.00	$10,000.00
109-1	Mobilization	1 L.S.	30,000.00	30,000.00
201-1	Clearing and Grubbing	1 L.S.	5,000.00	5,000.00
215-1	Channel Excavation	59,825 C.Y.	3.50	209,387.50
220-1	Grouted Riprap	3,240 S.Y.	22.00	71,280.00
310-1	Aggregate Base Course	1,315 Ton	16.00	21,040.00
350-1	Removal of Exist. Improvements	1 L.S.	5,000.00	5,000.00
401-1	Traffic Control	1 L.S.	4,000.00	4,000.00
415-1	Guard Rail and Appurtenances	381 L.F.	20.00	7,620.00
421-1	4-Wire Fence	8,085 L.F.	4.50	36,382.50
421-2	14' Type 1 Single Gate	5 Ea.	200.00	1,000.00
~~421-3~~	~~22' Type 1 Double Gate~~	~~1 Ea.~~	~~500.00~~	~~500.00~~

FLOOD CONTROL DISTRICT OF MARICOPA COUNTY	WHITE TANKS FRS #4 INLET CHANNEL IMPROVEMENTS Contract No. 92-38

ENGINEER'S ESTIMATE

PAY ITEM NO.	DESCRIPTION	APPROX. QUANTITY & UNIT	UNIT PRICE	AMOUNT
505-1	Class "A" Concrete (Ret. Wall)	130 C.Y.	$250.00	$32,500.00
505-2	Reinforcing Steel (Ret. Wall)	8,913 LB.	0.50	4,456.50
505-3	Concrete Channel Liner - 6"	21,118 S.Y.	26.00	549,068.00
505-4	Concrete Channel Liner - 7"	7,245 S.Y.	30.00	217,350.00
505-5	Concrete Channel Liner - 9"	5,435 S.Y.	36.00	195,660.00
505-6	Concrete Cutoff Wall	10,266 L.F.	12.00	123,192.00
618-1	Storm Drain Culvert Extension	10 L.F.	120.00	1,200.00
618-2	Storm Drain Flap Gates	2 Ea.	6,000.00	12,000.00
			TOTAL:	$1,514,636.50
			USE:	**$1,515,000.00**

FLOOD CONTROL DISTRICT
OF MARICOPA COUNTY

WHITE TANKS FRS #4
INLET CHANNEL IMPROVEMENTS
Contract No. 92-38

QUANTITY SUMMARY

PAY ITEM NO.	DESCRIPTION	APPROX. QUANTITY & UNIT	Gen. Cond	5	6	7	8	9	10	11
107-1	NPDES Permit Requirements	1 L.S.	1							
109-1	Mobilization	1 L.S.	1							
201-1	Clearing and Grubbing	1 L.S.	1							
215-1	Channel Excavation	59,825 C.Y.		11529.00	9835.00	12185.00	5664.00	6427.00	9712.00	4473.00
220-1	Grouted Riprap	3,240 S.Y.		3240.00						
310-1	Aggregate Base Course	1,315 Ton		220.00	245.00	250.00	120.00	165.00	190.00	125.00
350-1	Removal of Exist. Improvements	1 L.S.	1							
401-1	Traffic Control	1 L.S.	1							
415-1	Guard Rail and Appurtenances	381 L.F.						381		
421-1	4-Wire Fence	8,085 L.F.		746.00	1745.00	1847.00	600.00	860.00	1146.00	1141.00
421-2	14' Type 1 Single Gate	5 Ea.		1.00	1.00		1.00	1.00	1.00	
421-3	22' Type 1 Double Gate	1 Ea.								1.00
505-1	Class "A" Concrete (Ret. Wall)	130 C.Y.					15.00	115.00		
505-2	Reinforcing Steel (Ret. Wall)	8,913 LB.					1290.00	7623.00		
505-3	Concrete Channel Liner - 6"	21,118 S.Y.		94.00	6430.00	4339.00	2471.00	6070.00	1714.00	
505-4	Concrete Channel Liner - 7"	7,245 S.Y.				1360.00	720.00		2715.00	2450.00
505-5	Concrete Channel Liner - 9"	5,435 S.Y.		1855.00		830.00	890.00	715.00	835.00	310.00
505-6	Concrete Cutoff Wall	10,266 L.F.		895.00	1710.00	1996.00	1260.00	1826.00	1568.00	1011.00
618-1	Storm Drain Culvert Extension	10 L.F.						10.00		
618-2	Storm Drain Flap Gates	2 Ea.					1.00	1.00		

DIBBLE & ASSOCIATES

CONSULTING ENGINEERS

CALC KLS DATE 6/11/94 TITLE WHITE TANKS #4 FRS JOB 9302

CHKD ..... DATE ..... RET. WALL QTTYS SHT 1 OF .....

WALLS W-1 & W-2

DETAIL : B-18.10

LENGTH = 7.5'(2) + 11' + 17' = 43 LF

SHEDULE : 5' CASE III

CONC = 0.353 CY/LF (43 LF) = 15.2 CY

STEEL = 30#/LF (43 LF) = 1290 LB

WALL W-3

A: DETAIL: B-19.10

L = 12' , SCHEDULE = 9' CASE III

CONC = 12'(0.676) = 8.1 CY

STEEL = 12'(55) = 660 LB

B: DETAIL B-19.40

L = 60' + 45.5 SCHED. = 9'

CONC = 0.846 (105.5) = 89.3

STEEL = 55 (105.5) = 5803

L = 29' SCHED = 6'

CONC = 0.619 (29) = 18

REINF = 40 (29) = 1160

SLOPE-LINER CALCULATOR SLPCALC

NO.	SIDE	MATL	KEY	START STA	START HGHT	START SLOPE X:1	END STA	END HGHT FT	END SLOPE X:1	DEPTH FT	BEGIN SLOPE L FT	END SLOPE L FT	CURVE ADJ.	STATION LENGTH FT	AREA SY	VOLUME CY	AREA 7" APRON SY	AREA 14" RIPRAP SY	AREA 6" APRON SY	AREA 9" APRON SY
SHEET 1																				
1	R=9"CONC	4	1079.8	10	2	1495.0	10	2	0.75	22.4	22.4	1.04	431.78	1072.76	268.19					1072.76
2	L=9"CONC	4	1495.0	6.6	4	1550.0	9.4	2	0.75	27.2	21.0	1.00	55.00	147.37	36.84					147.37
3	C=9"CONC	4	1495.0			1550.0			0.75	75.0	65.0	1.00	55.00	427.78	106.94					427.78
4	R=9"CONC	4	1495.0	5.4	2	1550.0	8.3	2	0.75	12.1	18.6	1.00	55.00	93.60	23.40					93.60
5	L=9"CONC	4	1550.0	9.4	2	1560.0	6	2	0.75	21.0	13.4	1.00	10.00	19.13	4.78					19.13
6	C=9"CONC	4	1550.0			1560.0			0.75	65.0	65.0	1.00	10.00	72.22	18.06					72.22
7	R=9"CONC	4	1550.0	9.3	2	1560.0	6	2	0.75	20.8	13.4	1.00	10.00	19.01	4.75					19.01
8	L=RIPRAP	2	1560.0	6	2	1931.3	6.6	2	1.02	13.4	14.8	1.12	415.86	650.92	221.31			650.92		
9	C=RIPRAP	2	1560.0			1931.3			1.02	65.0	36.0	1.00	371.30	2083.41	708.36			2083.41		
10	R=RIPRAP	2	1560.0	6	2	1931.3	6.6	2	1.02	13.4	14.8	0.87	323.03	505.62	171.91			505.62		
																	0.00	3239.95	0.00	1851.87
SHEET 2																				
11	L=6"CONC	3	1931.3	6.6	2	2375.0	6.6	2	0.50	14.8	14.8	1.00	443.70	727.57	121.26				727.57	
12	C=6"CONC	3	1931.3			2375.0			0.50	36.0	36.0	1.00	443.70	1774.80	295.80				1774.80	
13	R=6"CONC	3	1931.3	6.6	2	2375.0	6.6	2	0.50	14.8	14.8	1.00	443.70	727.57	121.26				727.57	
14	L=6"CONC	3	2375.0	6.6	2	2425.0	6.6	2	0.50	14.8	14.8	1.00	50.00	81.99	13.66				81.99	
15	C=6"CONC	3	2375.0			2425.0			0.50	36.0	36.0	1.00	50.00	200.00	33.33				200.00	
16	R=6"CONC	3	2375.0	6.6	2	2425.0	7.1	2	0.50	14.8	15.9	1.00	50.00	85.09	14.18				85.09	
17	L=6"CONC	3	2425.0	6.6	2	2776.3	6.6	4	0.50	14.8	27.2	0.95	333.74	778.17	129.69				778.17	
18	C=6"CONC	3	2425.0			2776.3			0.50	36.0	36.0	1.00	351.30	1405.20	234.20				1405.20	
19	R=6"CONC	3	2425.0	7.1	2	2776.3	7.1	2	0.50	15.9	15.9	1.05	368.87	650.68	108.45				650.68	
																	0.00	0.00	6431.08	0.00
SHEET 3																				
20	L=6"CONC	3	2776.3	6.6	2	2800.0	6.6	2	0.50	14.8	14.8	1.00	23.69	38.85	6.47				38.85	
21	C=6"CONC	3	2776.3			2800.0			0.50	36.0	36.0	1.00	23.70	94.80	15.80				94.80	
22	R=6"CONC	3	2776.3	7.1	2	2800.0	6.6	2	0.50	15.9	14.8	1.00	23.70	40.33	6.72				40.33	
23	L=9"CONC	4	2800.0	6.6	2	2837.0	9.3	2	0.75	14.8	20.8	1.00	37.00	73.08	18.27					73.08
24	C=9"CONC	4	2800.0			2837.0			0.75	36.0	36.0	1.00	37.00	148.00	37.00					148.00
25	R=9"CONC	4	2800.0	6.6	2	2837.0	9.3	2	0.75	14.8	20.8	1.00	37.00	73.08	18.27					73.08
26	L=9"CONC	4	2837.0	9.3	2	2885.0	9.5	2	0.75	20.8	21.2	1.00	48.00	112.10	28.03					112.10
27	C=9"CONC	4	2837.0			2885.0			0.75	36.0	36.0	1.00	48.00	192.00	48.00					192.00
28	R=9"CONC	4	2837.0	9.3	2	2885.0	9.5	2	0.75	20.8	21.2	1.00	48.00	112.10	28.03					112.10
29	L=9"CONC	4	2885.0	9.5	2	2900.0	5.6	2	0.75	21.2	12.5	1.00	15.00	28.14	7.03					28.14
30	C=9"CONC	4	2885.0			2900.0			0.75	36.0	36.0	1.00	15.00	60.00	15.00					60.00
31	R=9"CONC	4	2885.0	9.5	2	2900.0	5.6	2	0.75	21.2	12.5	1.00	15.00	28.14	7.03					28.14
32	L=6"CONC	3	2900.0	5.6	2	3500.0	5.6	2	0.50	12.5	12.5	1.00	600.00	834.80	139.13				834.80	
33	C=6"CONC	3	2900.0			3500.0			0.50	36.0	36.0	1.00	600.00	2400.00	400.00				2400.00	
34	R=6"CONC	3	2900.0	5.6	2	3500.0	5.6	2	0.50	12.5	12.5	1.00	600.00	834.80	139.13				834.80	
35	L=7"CONC	1	3500.0	5.6	2	3700.0	5.6	2	0.58	12.5	12.5	1.00	200.00	278.27	53.80		278.27			
36	C=7"CONC	1	3500.0			3700.0			0.58	36.0	36.0	1.00	200.00	800.00	154.67		800.00			
37	R=7"CONC	1	3500.0	5.6	2	3700.0	5.6	2	0.58	12.5	12.5	1.00	200.00	278.27	53.80		278.27			
																	1356.53	0.00	4243.58	826.64

SLOPE-LINER CALCULATOR SLPCALC

NO.	SIDE	MATL	KEY	START STA	START HGHT	START SLOPE X:1	END STA	END HGHT FT	END SLOPE X:1	DEPTH FT	BEGIN SLOPE L FT	END SLOPE L FT	CURVE ADJ.	STATION LENGTH FT	AREA SY	VOLUME CY	AREA 7" APRON SY	AREA 14" RIPRAP SY	AREA 6" APRON SY	AREA 9" APRON SY
SHEET 4																				
35		L=7"CONC	1	3700.0	5.6	2	3800.0	7.3	2	0.58	12.5	16.3	1.00	100.00	160.25	30.98	160.25			
36		C=7"CONC	1	3700.0			3800.0			0.58	36.0	36.0	1.00	100.00	400.00	77.33	400.00			
37		R=7"CONC	1	3700.0	5.6	2	3800.0	7.3	2	0.58	12.5	16.3	1.00	100.00	160.25	30.98	160.25			
38		L=6"CONC	3	3800.0	7.3	2	4008.2	7.3	2	0.50	16.3	16.3	1.00	208.23	377.67	62.94			378	
39		C=6"CONC	3	3800.0			4008.2			0.50	36.0	36.0	1.00	208.20	832.80	138.80			833	
40		R=6"CONC	3	3800.0	7.3	2	4008.2	7.3	2	0.50	16.3	16.3	1.00	208.20	377.61	62.94			378	
41		L=6"CONC	3	4008.2	7.3	2	4095.0	7.3	2	0.50	16.3	16.3	1.00	86.80	157.43	26.24			157	
42		C=6"CONC	3	4008.2			4095.0			0.50	36.0	46.6	1.00	86.80	398.32	66.39			398	
43		R=6"CONC	3	4008.2	7.3	2	4095.0	7.3	2	0.50	16.3	16.3	1.00	86.80	157.43	26.24			157	
44		L=9"CONC	4	4095.0	7.3	2	4163.0	9	2	0.75	16.3	20.1	1.00	68.00	137.69	34.42				138
45		C=9"CONC	4	4095.0			4163.0			0.75	46.6	57.0	1.00	68.00	391.38	97.84				391
46		R=9"CONC	4	4095.0	7.3	2	4163.0	9	2	0.75	16.3	20.1	1.00	68.00	137.69	34.42				138
47		L=9"CONC	4	4163.0	9	2	4175.0	5	2	0.75	20.1	11.2	1.00	12.00	20.87	5.22				21
48		C=9"CONC	4	4163.0			4175.0			0.75	57.0	60.0	1.00	12.00	78.00	19.50				78
49		R=9"CONC	4	4163.0	9	2	4175.0	5	2	0.75	20.1	11.2	1.00	12.00	20.87	5.22				21
50		C=9"CONC	4	4175.0			4190.0			0.75	60.0	60.0	1.00	15.00	100.00	25.00				100
51		C=6"CONC	3	3800.0			3840.0			0.50	0.0	14.0	1.00	40.00	31.11	5.19			31	
52		C=6"CONC	3	3840.0			3918.0			0.50	14.0	14.0	1.00	78.00	121.33	20.22			121	
																	720.50	0.00	2453.70	886.50
SHEET 5																				
53		L=6"CONC	3	4712.0	4.2	2	4737.0	6	2	0.50	9.4	13.4	1.00	25.00	31.68	5.28			32	
54		R=6"CONC	3	4712.0	4.2	2	4737.0	6	2	0.50	9.4	13.4	1.00	25.00	31.68	5.28			32	
53		LL6"CONC	3	0.0	5	2	40.5	6	2	0.50	11.2	13.4	1.00	40.50	55.34	9.22			55	
54		LC6"CONC	3	0.0			40.5			0.50	10.0	10.0	1.00	40.50	45.00	7.50			45	
55		LR6"CONC	3	0.0	5	2	40.5	6	2	0.50	11.2	13.4	1.00	40.50	55.34	9.22			55	
56		L=6"CONC	3	4760.0	6	2	5092.0	6	2	0.50	13.4	13.4	1.00	332.00	494.92	82.49			495	
57		C=6"CONC	3	4737.9			5092.0			0.50	50.0	50.0	1.00	354.10	1967.22	327.87			1967	
58		R=6"CONC	3	4737.9	6	2	5092.0	6	2	0.50	13.4	13.4	1.00	354.10	527.86	87.98			528	
59		C=6"CONC	3	4800.0			4840.0			0.50	0.0	14.0	1.00	40.00	31.11	5.19			31	
60		C=6"CONC	3	4840.0			4920.0			0.50	14.0	14.0	1.00	80.00	124.44	20.74			124	
61		L=9"CONC	4	5092.0	6	2	5129.0	8.3	2	0.75	13.4	18.6	1.00	37.00	65.73	16.43				66
62		C=9"CONC	4	5092.0			5129.0			0.75	50.0	51.0	1.00	37.00	207.61	51.90				208
63		R=9"CONC	4	5092.0	6	2	5120.0	8	2	0.75	13.4	17.9	1.00	28.00	48.70	12.17				49
64		L=9"CONC	4	5129.0	8.3	2	5170.0	8.5	2	0.75	18.6	19.0	1.00	41.00	85.57	21.39				86
65		C=9"CONC	4	5129.0			5170.0			0.75	51.0	51.0	1.00	41.00	232.33	58.08				232
66		R= WALL	5	5129.0	8.3	1	5162.0	8.5	1	0.75	11.7	12.0	1.00	33.00	43.56	10.89				
67		L=9"CONC	4	5170.0	8.5	2	5180.0	5	2	0.75	19.0	11.2	1.00	10.00	16.77	4.19				17
68		C=9"CONC	4	5170.0			5180.0			0.75	51.0	51.0	1.00	10.00	56.67	14.17				57
69		R= WALL	5	5162.0	8.5	1	5180.0	5	1	0.50	12.0	7.1	1.00	18.00	19.09	3.18				
70		L=6"CONC	3	5180.0	5	2	5235.5	5	2	0.50	11.2	11.2	1.00	55.50	68.95	11.49			69	
71		C=6"CONC	3	5180.0			5235.5			0.50	50.0	50.0	1.00	55.50	308.33	51.39			308	
72		LL6"CONC	3	0.0	4	2	66.0	5	2	0.50	8.9	11.2	1.00	66.00	73.79	12.30			74	
73		LC6"CONC	3	0.0			66.0			0.50	10.0	10.0	1.00	66.00	73.33	12.22			73	
74		LR6"CONC	3	0.0	4	2	66.0	6.2	2	0.50	8.9	13.9	1.00	66.00	83.63	13.94			84	

SLOPE-LINER CALCULATOR SLPCALC

NO.	SIDE	MATL	KEY	START STA	START HGHT	START SLOPE X:1	END STA	END HGHT FT	END SLOPE X:1	DEPTH FT	BEGIN SLOPE L FT	END SLOPE L FT	CURVE ADJ.	STATION LENGTH FT	AREA SY	VOLUME CY	AREA 7" APRON SY	AREA 14" RIPRAP SY	AREA 6" APRON SY	AREA 9" APRON SY
75		L=6"CONC	3	5365.0	7.2	2	5434.3	7	2	0.50	16.1	15.7	1.00	69.30	122.25	20.37			122	
76		C=6"CONC	3	5322.5			5434.3			0.50	50.0	36.0	1.00	111.80	534.16	89.03			534	
77		R=6"CONC	3	5375.0	7.2	2	5434.3	7.00	2	0.50	16.1	15.7	1.00	59.30	104.61	17.43			105	
78		L=6"CONC	3	5434.5	7.0	2	5607.0	6.7	2	0.50	15.7	15.0	1.00	172.50	293.58	48.93			294	
79		C=6"CONC	3	5434.5			5607.0			0.50	36.0	36.0	1.00	172.50	690.00	115.00			690	
80		R=6"CONC	3	5434.5	7.0	2	5607.0	6.7	2	0.50	15.7	15.0	1.00	172.50	293.58	48.93			294	
																	0.00	0.00	6010.79	713.37
SHEET 6																				
81		L=6"CONC	3	5600.0	6.7	2	5800.0	6.7	2	0.50	15.0	15.0	1.00	200.00	332.93	55.49			333	
82		C=6"CONC	3	5600.0			5800.0			0.50	36.0	36.0	1.00	200.00	800.00	133.33			800	
83		R=6"CONC	3	5600.0	6.7	2	5800.0	6.7	2	0.50	15.0	15.0	1.00	200.00	332.93	55.49			333	
84		C=6"CONC	3	5601.0			5641.0			0.50	0.0	14.0	1.00	40.00	31.11	5.19			31	
85		C=6"CONC	3	5641.0			5720.0			0.50	14.0	14.0	1.00	79.00	122.89	20.48			123	
86		L=9"CONC	4	5800.0	6.7	2	5837.0	9.3	2	0.75	15.0	20.8	1.00	37.00	73.54	18.39				74
87		C=9"CONC	4	5800.0			5837.0			0.75	36.0	36.0	1.00	37.00	148.00	37.00				148
88		R=9"CONC	4	5800.0	6.7	2	5837.0	9.3	2	0.75	15.0	20.8	1.00	37.00	73.54	18.39				74
89		L=9"CONC	4	5837.0	9.3	2	5885.0	10	2	0.75	20.8	22.4	1.00	48.00	115.08	28.77				115
90		C=9"CONC	4	5837.0			5885.0			0.75	36.0	36.0	1.00	48.00	192.00	48.00				192
91		R=9"CONC	4	5837.0	9.3	2	5885.0	10	2	0.75	20.8	22.4	1.00	48.00	115.08	28.77				115
92		L=9"CONC	4	5885.0	10	2	5900.0	5.6	2	0.75	22.4	12.5	1.00	15.00	29.07	7.27				29
93		C=9"CONC	4	5885.0			5900.0			0.75	36.0	36.0	1.00	15.00	60.00	15.00				60
94		R=9"CONC	4	5885.0	10	2	5900.0	5.6	2	0.75	22.4	12.5	1.00	15.00	29.07	7.27				29
95		L=7"CONC	1	5900.0	5.6	2	6300.0	5.6	2	0.58	12.5	12.5	1.00	400.00	556.53	107.60	556.53			
96		C=7"CONC	1	5900.0			6300.0			0.58	36.0	36.0	1.00	400.00	1600.00	309.33	1600.00			
97		R=7"CONC	1	5900.0	5.6	2	6300.0	5.6	2	0.58	12.5	12.5	1.00	400.00	556.53	107.60	556.53			
																	2713.06	0.00	1619.85	835.39
SHEET 7																				
98		L=7"CONC	1	6300.0	5.6	2	6340.0	5.6	2	0.58	12.5	12.5	1.00	40.00	55.65	10.76	55.65			
99		C=7"CONC	1	6300.0			6340.0			0.58	36.0	36.0	1.00	40.00	160.00	30.93	160.00			
100		R=7"CONC	1	6300.0	5.6	2	6340.0	5.6	2	0.58	12.5	12.5	1.00	40.00	55.65	10.76	55.65			
101		L=7"CONC	1	6340.0	5.6	2	6440.0	6.6	2	0.58	12.5	14.8	1.00	100.00	151.56	29.30	151.56			
102		C=7"CONC	1	6340.0			6440.0			0.58	36.0	36.0	1.00	100.00	400.00	77.33	400.00			
103		R=7"CONC	1	6340.0	5.6	2	6440.0	6.6	2	0.58	12.5	14.8	1.00	100.00	151.56	29.30	151.56			
104		L=7"CONC	1	6440.0	6.6	2	6620.9	6.6	2	0.58	14.8	14.8	1.00	180.93	296.69	57.36	296.69			
105		C=7"CONC	1	6440.0			6620.9			0.58	36.0	36.0	1.00	180.93	723.72	139.92	723.72			
106		R=7"CONC	1	6440.0	6.6	2	6620.9	6.6	2	0.58	14.8	14.8	1.00	180.90	296.64	57.35	296.64			
107		R=9"CONC	4	6620.9	10.6	2	6700.0	9.6	2	0.75	23.7	21.5	1.00	79.10	198.49	49.62				198
108		R=9"CONC	4	6700.0	9.6	2	6751.9	9.0	1.5	0.75	21.5	16.2	1.00	51.93	108.74	27.18				109
109		C=7"CONC	1	6660.0			6700.0			0.58	0.0	14.0	1.00	40.00	31.11	6.01	31.11			
110		C=7"CONC	1	6700.0			6780.0			0.58	14.0	14.0	1.00	80.00	124.44	24.06	124.44			
																	2447.02	0.00	0.00	307.23
																TOTALS	7237.11	3239.94	20758.9	5421.00

FCD PROJECT NO. 92-38 WHITE TANKS #4 FRS INLET CHANNEL ROADCLC

ABC ROADWAY BASE CALCULATOR ABC @ 140 LB/CF

NO.	SIDE	MATL	START STA	END STA	DEPTH FT	CURVE ADJ.	ACTUAL LENGTH FT	ROAD WIDTH FT	AREA SY	VOLUME CY	VOLUME TONS
SHEET 1											
1	R=4"	ABC	1079.8	1116.3	0.33	1.00	36.4	12	48.56	5.34	10.1
2	R=4"	ABC	1116.3	1456.3	0.33	1.07	363.9	12	485.18	53.37	100.9
3	R=4"	ABC	1456.3	1523.0	0.33	1.00	66.7	12	88.89	9.78	18.5
4	R=4"	ABC	1548.0	1620.3	0.33	1.00	72.3	12	96.45	10.61	20.1
5	R=4"	ABC	1620.3	1931.3	0.33	0.82	255.0	12	339.97	37.40	70.7
									1059.06	116.50	220.18
SHEET 2											
6	R=4"	ABC	1931.3	2424.0	0.33	1.00	492.7	12	656.97	72.27	136.6
7	R=4"	ABC	2424.0	2776.3	0.33	1.11	391.0	12	521.39	57.35	108.4
									1178.36	129.62	244.98
SHEET 3											
8	R=4"	ABC	2776.3	2840.0	0.33	1.00	63.7	12	84.93	9.34	17.7
9	R=4"	ABC	2865.0	3700.0	0.33	1.00	835.0	12	1113.33	122.47	231.5
									1198.27	131.81	249.12
SHEET 4											
10	R=4"	ABC	3700.0	4008.0	0.33	1.00	308.0	12	410.67	45.17	85.4
11	R=4"	ABC	4008.0	4100.0	0.33	1.33	122.4	12	163.15	17.95	33.9
									573.81	63.12	119.30
SHEET 5											
12	L=4"	ABC	4750.0	5200.0	0.33	1.00	450.0	12	600.00	66.00	124.7
13	L=4"	ABC	5434.0	5543.0	0.33	0.71	77.4	12	103.19	11.35	21.5
14	R=4"	ABC	5536.0	5600.0	0.33	1.00	64.0	12	85.33	9.39	17.7
									788.52	86.74	163.93
SHEET 6											
15	R=4"	ABC	5600.0	5840.0	0.33	1.00	240.0	12	320.00	35.20	66.5
16	R=4"	ABC	5865.0	6300.0	0.33	1.00	435.0	12	580.00	63.80	120.6
									900.00	99.00	187.11
SHEET 7											
17	R=4"	ABC	6300.0	6751.0	0.33	1.00	451.0	12	601.33	66.15	125.0

R O A D C A L C

C RATOR: DIBBLE & ASSOCIATES ENGINEERS TITLE: DESIGN EARTHWORK: RAW VOLUMES DATE: 07-27-94
P JECT: 302 - WHITE TANKS FRS #4 INLET CHANNEL PAGE: 1 TIME: 12:49:01

STATION	CUT AREA (SF)	CUT VOL (CY)	FILL AREA (SF)	FILL VOL (CY)	SERV. RD CUT (CY)	SERV. RD FILL (CY)	ADJ. CUT (CY)	ADJ. FILL (CY)	SHRINK (CY)	WASTE (CY)
1079.83	46	0	90	0						
1116.25	52	66	89	120						
1116.26	54	0	90	0						
1200.00	114	257	89	295						
1300.00	248	656	115	402						
1400.00	463	1293	171	572						
1456.33	671	1166	210	437						
1495.00	740	1010	238	321						
1495.01	801	0	237	0						
1500.00	783	146	259	46						
1550.00	664	1339	392	602						
1560.00	330	184	498	165						
1560.01	365	0	493	0						
1600.00	370	545	417	673						
1620.34	355	273	396	306						
1700.00	373	1083	255	581						
1800.00	462	1564	224	639						
1900.00	355	1552	202	608						
1931.28	303	395	138	159						
1931.29	264	0	146	0						
2000.00	201	591	62	265						

==========SHEET 5==========

0	117	11529	5809	581	5139

STATION	CUT AREA (SF)	CUT VOL (CY)	FILL AREA (SF)	FILL VOL (CY)	SERV. RD CUT (CY)	SERV. RD FILL (CY)	ADJ. CUT (CY)	ADJ. FILL (CY)	SHRINK (CY)	WASTE (CY)
2040.00	309	378	1	47						
2100.00	279	654	0	1						
2120.00	267	202	6	2						
2120.01	265	0	7	0						
2200.00	275	800	1	12						
2300.00	336	1132	0	2						
2400.00	368	1303	0	0						
2500.00	364	1393	1	1						
2600.00	438	1542	0	1						
					==========SHEET 6==========					
2700.00	474	1723	1	3						
					117	13	9835	321	32	9482
2800.00	486	1775	12	26						
2837.00	468	654	78	62						
2877.00	523	734	108	138						
2900.00	255	331	147	109						
3000.00	258	950	81	423						
3100.00	274	985	138	407						
3145.00	295	474	125	220						
3200.00	270	576	134	264						
3300.00	267	994	140	508						
3335.00	269	347	126	173						
3400.00	271	650	112	287						
3500.00	318	1092	97	388						
3600.00	337	1214	128	417						

STATION	CUT AREA (SF)	CUT VOL (CY)	FILL AREA (SF)	FILL VOL (CY)	SERV. RD CUT (CY)	SERV. RD FILL (CY)	ADJ. CUT (CY)	ADJ. FILL (CY)	SHRINK (CY)	WASTE (CY)
					==========SHEET 7==========					
3645.00	382	599	104	193						
					13	119	12185	3699	8116	
3700.00	401	797	96	203						
3800.00	296	1291	228	600						
3838.00	346	452	181	287						
3900.00	328	774	218	457						
3918.00	339	223	234	147						
3918.01	254	0	246	0						
4000.00	316	886	185	493						
4100.33	283	1116	24	382						
4095.00	283	0	24	0						
4157.00	347	723	0	28						
4175.00	85	144	8	3						
					==========SHEET 8==========					
4190.00	67	42	0	2						
					13	51	5664	2348	235	3081
4712.00	0	643	0	0						
4733.00	0	0	0	0						
4741.00	51	8	142	22						
4750.00	72	20	41	31						
4800.00	123	181	53	86						
4840.00	230	262	30	61						
4900.00	206	484	28	64						
4920.00	205	152	29	21						
4920.01	205	0	33	0						
5000.00	276	712	11	64						

STATION	CUT AREA (SF)	CUT VOL (CY)	FILL AREA (SF)	FILL VOL (CY)	SERV. RD CUT (CY)	SERV. RD FILL (CY)	ADJ. CUT (CY)	ADJ. FILL (CY)	SHRINK (CY)	WASTE (CY)
5100.00	326	1114	0	19						
5120.10	298	232	14	5						
5120.00	273	0	34	0						
5120.12	273	-1	35	0						
5129.00	276	90	46	13						
5145.00	275	163	53	29						
5162.00	285	176	41	29						
5180.00	75	120	41	27						
5200.00	77	56	31	27						
5250.00	0	71	0	29						
5278.71	0	0	0	0						
5279.63	0	0	0	0						
5300.00	0	0	0	0						
5323.00	17	7	61	26						
5400.00	68	117	136	278						
5434.27	142	129	280	286						
5500.00	261	490	328	740						
5543.53	294	449	285	378						
5536.64	294	0	285	0						
5537.52	295	10	284	7						
					==========SHEET 9==========					
5600.00	332	725	205	566						
					17	70	6427	2738	274	3415
5640.00	561	661	95	222						
5700.00	441	1113	112	229						

STATION	CUT AREA (SF)	CUT VOL (CY)	FILL AREA (SF)	FILL VOL (CY)	SERV. RD CUT (CY)	SERV. RD FILL (CY)	ADJ. CUT (CY)	ADJ. FILL (CY)	SHRINK (CY)	WASTE (CY)
5720.00	434	324	111	83						
5720.01	429	0	111	0						
5800.00	534	1426	121	344						
5837.00	495	705	136	177						
5885.00	518	900	171	273						
5900.00	214	203	188	100						
6000.00	254	865	169	662						
6100.00	303	1031	117	530						
6200.00	336	1183	104	409						
					==========SHEET 10==========					
6300.00	349	1268	104	385						
					33	66	9712	3348	335	6029
6340.00	362	527	105	155						
6400.00	274	707	133	264						
6440.00	236	378	184	234						
6500.00	331	625	145	300						
6590.90	299	1050	166	392						
6592.90	299	22	156	11						
6600.00	303	79	155	41						
6620.93	302	235	141	115						
6751.83	43	837	0	395						
					==========SHEET 11==========					
6736.01	0	0	0	0						
					13	53	4473	1854	185	2434
TOTALS		59622		20611						
					==========GRAND TOTAL==========					
							59825	20117	2012	37696

R O A D C A L C

C RATOR: DIBBLE & ASSOCIATES ENGINEERS TITLE: DESIGN EARTHWORK: MASS VOLUMES DATE: 07-27-94
PROJECT: 302 - WHITE TANKS FRS #4 INLET CHANNEL PAGE: 1 TIME: 12:49:01

STATION	CUT + X CUT - WASTE (CY)	FILL + CMP X FILL - BORROW (CY)	MASS ORDINATE (CY)
1079.83	0	0	0
1116.25	66	133	-67
1116.26	0	0	-67
1200.00	257	324	-134
1300.00	656	442	81
1400.00	1293	630	744
1456.33	1166	481	1428
1495.00	1010	353	2085
1495.01	0	0	2085
1500.00	146	50	2181
1550.00	1339	663	2858
1560.00	184	181	2861
1560.01	0	0	2861
1600.00	545	741	2664
1620.34	273	336	2601
1700.00	1083	639	3044
1800.00	1564	703	3906
1900.00	1552	669	4788
1931.28	395	175	5008
1931.29	0	0	5008
2000.00	591	291	5308

STATION	CUT + X CUT - WASTE (CY)	FILL + CMP X FILL - BORROW (CY)	MASS ORDINATE (CY)
2040.00	378	51	5635
2100.00	654	2	6288
2120.00	202	3	6487
2120.01	0	0	6488
2200.00	800	13	7275
2300.00	1132	2	8404
2400.00	1303	0	9707
2500.00	1393	1	11099
2600.00	1542	1	12640
2700.00	1723	3	14360
2800.00	1775	29	16106
2837.00	654	68	16692
2877.00	734	152	17273
2900.00	331	120	17484
3000.00	950	466	17968
3100.00	985	447	18505
3145.00	474	242	18738
3200.00	576	291	19023
3300.00	994	559	19458
3335.00	347	190	19615
3400.00	650	316	19950
3500.00	1092	427	20615
3600.00	1214	459	21371

STATION	CUT + X CUT - WASTE (CY)	FILL + CMP X FILL - BORROW (CY)	MASS ORDINATE (CY)
3645.00	599	212	21758
3700.00	797	223	22332
3800.00	1291	660	22963
3838.00	452	316	23099
3900.00	774	503	23369
3918.00	223	162	23430
3918.01	0	0	23430
4000.00	886	542	23774
4095.00	1116	420	24470
4157.00	723	31	25163
4175.00	144	3	25303
4190.00	42	3	25343
4712.00	643	0	25986
4733.00	0	0	25986
4741.00	8	24	25970
4750.00	20	34	25957
4800.00	181	95	26042
4840.00	262	67	26237
4900.00	484	71	26650
4920.00	152	23	26779
4920.01	0	0	26779
5000.00	712	71	27420
5100.00	1114	21	28512

STATION	CUT + X CUT - WASTE (CY)	FILL + CMP X FILL - BORROW (CY)	MASS ORDINATE (CY)
5120.00	232	6	28739
5120.12	-1	0	28738
5129.00	90	15	28814
5145.00	163	32	28945
5162.00	176	32	29089
5180.00	120	30	29179
5200.00	56	29	29206
5250.00	71	32	29245
5279.63	0	0	29245
5300.00	0	0	29245
5323.00	7	28	29224
5400.00	117	306	29036
5434.27	129	315	28849
5500.00	490	814	28526
5536.64	449	416	28558
5537.52	10	8	28560
5600.00	725	623	28662
5640.00	661	245	29079
5700.00	1113	252	29940
5720.00	324	91	30173
5720.01	0	0	30173
5800.00	1426	378	31221
5837.00	705	194	31732

STATION	CUT + X CUT - WASTE (CY)	FILL + CMP X FILL - BORROW (CY)	MASS ORDINATE (CY)
5885.00	900	301	32332
5900.00	203	110	32425
6000.00	865	729	32562
6100.00	1031	583	33010
6200.00	1183	450	33742
6300.00	1268	424	34586
6340.00	527	170	34943
6400.00	707	291	35359
6440.00	378	258	35479
6500.00	625	330	35775
6590.90	1050	431	36393
6592.90	22	12	36404
6600.00	79	45	36438
6620.93	235	126	36547
6736.01	837	434	36949