APPENDIX A3.2
FLOW COMPUTATION METHODS USED TO CALCULATE EAA BASIN FLOWS

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GATED SPILLWAYS

Parameters

C_{cf}	=	discharge coefficient for controlled free flow
C_{cs}	=	discharge coefficient for controlled submerged flow
C_{ot}	=	discharge coefficient for over-the-top flow
C_{uf}	=	discharge coefficient for uncontrolled free flow
C_{us}	=	discharge coefficient for uncontrolled submerged flow
G_o	=	gate opening, in feet
g	=	acceleration due to gravity, 32.2ft/sec^2
H	=	approach head over the spillway sill, which is the difference between the upstream stage and the sill elevation, in feet
H_g	=	approach head over the gate, in feet
h	=	submergence head over the spillway sill, which is the difference between the downstream stage and the sill elevation, in feet
L	=	length of spillway sill perpendicular to flow, in feet
n_1	=	exponent of approach head
n_2	=	exponent of submergence head
n_3	=	exponent of total head
n_4	=	exponent of gate opening
W	=	width of gate, in feet

Uncontrolled Free Flow

$$Q = C_{uf} L H^{n_1}$$

Spillway
S-5AS
S-7
S-8
S-351
S-352
S-354
G-371
G-373

Uncontrolled Submerged Flow

$$Q = C_{us} L h^{n_2} (H - h)^{n_3} \sqrt{2g}$$

Spillway
S-5AS
S-7
S-8
S-351
S-352
S-354
G-371
G-373

Controlled Free Flow

$$Q = C_{cf} L G_o \sqrt{2g(H - 0.5G_o)}$$

Spillway
S-5AS
S-7
S-8
S-351
S-352
S-354
G-371
G-373

Controlled Submerged Flow

$$Q = C_{cs} L G_o^{n_4} h^{n_2} \sqrt{2g(H-h)}$$

Spillway
S-5AS
S-7
S-8
S-351
S-352
S-354
G-371
G-373

Over-the-top Flow

$$Q = C_{ot} W H_g^{1.5} \sqrt{2g}$$

Spillway
S-5AS
S-7
S-8
S-351
S-352
S-354

PUMPS

Parameters

C	=	coefficient of discharge for siphon
C_0-C_9	=	coefficients of pump rating equation
H	=	head, downstream stage minus upstream stage, in feet
H_{fact}	=	normalizing head factor, in feet
H_{hi}	=	head from affinity laws corresponding to the high rpm rating equation, in feet
H_{lo}	=	head from affinity laws corresponding to the low rpm rating equation, in feet
N	=	engine speed, in rpm
N_{fact}	=	normalizing engine speed factor, in rpm
N_{hi}	=	engine speed of high rating equation, in rpm
N_{lo}	=	engine speed of low rating equation, in rpm
N_{min}	=	minimum engine speed below which no discharge is possible, in rpm
n	=	exponent of head for siphon
X	=	normalized head parameter
Y	=	normalized engine speed parameter

Pump Flow

Constant-speed Pump
A single-variable polynomial is used.

$$Q = C_0 + C_1 H + C_2 H^2 + C_3 H^3$$

Pump
G-200A
G-200B
G-349B
G-350B

Variable-speed Pump
Interpolation of single-variable polynomials is performed. The pump affinity laws are used to obtain the adjusted head, H_{lo}:

$$H_{lo} = H(\frac{N_{lo}}{N})^2$$

The adjusted head H_{lo} is used to compute Q_{lo}.

$$Q_{lo} = C_0 + C_1 H_{lo} + C_2 H_{lo}^2 + C_3 H_{lo}^3$$

Pump
S-5A
S-6
S-7
S-8
G-404
G-410
EBPS
ESPS
G-507
G-370
G-372
SSDD
SFCD
G-434
G-435
C-10
C-12A
C-12
C-4A
S236
EPD07

The adjusted head, H_{hi} is:

$$H_{hi} = H(\frac{N_{hi}}{N})^2$$

The adjusted head H_{hi} is used to compute Q_{hi}.

$$Q_{hi} = C_0 + C_1 H_{hi} + C_2 H_{hi}^2 + C_3 H_{hi}^3$$

The affinity laws are used to obtain the discharge Q at engine speed N:

$$Q = Q_{lo} + (Q_{hi} - Q_{lo})(\frac{N - N_{lo}}{N_{hi} - N_{lo}})$$

Variable-speed Pump with Very Variable Head
A two-variable polynomial used. The normalized head and engine speed are:

$$X = \frac{H}{H_{fact}}$$

$$Y = \frac{N - N_{\min}}{N_{fact}}$$

Pump
S-2
S-3

The pump discharge is:

$$Q = C_0 + C_1 X + C_2 Y + C_3 X^2 + C_4 XY + C_5 Y^2 + C_6 X^3 + C_7 YX^2 + C_8 XY^2 + C_9 Y^3$$

Siphon Flow
The siphon discharge is:

$$Q = CH^n$$

Siphon
S-6

CULVERTS

Refer to:

Fan, A. (October 1985). *A General Program to Compute Flow through Gated Culverts* (Technical Memorandum). West Palm Beach: South Florida Water Management District, West Palm Beach.

Parameters

The parameter defined here correspond to the variables defined by A. Fan.

Barrel	=	barrel shaped coding, “0” = circular, “1” = box
C	=	orifice flow coefficient due to inlet shape
C_w	=	weir flow coefficient (flashboard)
D	=	diameter of pipe culvert or height of box culvert, in feet
G_h	=	height of gate, in feet
G_{type}	=	gate type coding, “0” = circular, “1” = rectangular, “2” = weir
G_w	=	width of gate, in feet
IN_{el}	=	inlet invert elevation, in feet m.s.l. or NGVD
K	=	entrance loss coefficient due to shape of gate edge
L	=	length of culvert, in feet
N	=	number of barrels
n	=	Manning’s roughness coefficient
OUT_{el}	=	outlet invert elevation, in feet m.s.l or NGVD
r	=	refernece elevation for flashboard elevation, in feet m.s.l. or NGVD
S_{wb}	=	total side weir length (riser or wing wall), in feet
S_{we}	=	side weir crest elevation (riser or wing wall), in feet
W	=	width of box culvert
W_b	=	weir length (flashboad)

Culverts	Culverts
G-136	G-402A
G-88	G-402B
S-150	G-402C
S-5AE	G-402D
G-357	G-204
G-205	G-206
G-376A	G-376D
G-379A	G-379D
G-381A	G-381C
G-722	