

CORPS OF ENGINEERS
HYDRAULIC DESIGN CRITERIA

VOLUME 1

TABLE OF CONTENTS

	<u>Chart No.</u>
<u>PREFACE</u>	Page 1*
<u>CLASSIFICATION INDEX</u>	Page iii
List of CORPS Programs	Page xi*
CORPS - HDC Cross Reference	Page xiv*
 <u>GENERAL - 000</u>	
Physical Constants	
Acceleration of Gravity	
Effects of Latitude and Altitude	000-1
Barometric Data	
Altitude vs Pressure	000-2
Fluid Properties	
Effect of Temperature	*
Kinematic Viscosity of Water	001-1*
Vapor Pressure of Water	001-2
Surface Tension of Water	001-3
Bulk Modulus of Water	001-4
Speed of Sound in Water	001-5
Open Channel Flow	
Surface Curve Classifications	
Uniform Slopes	010-1
Backwater Computations	
Definition and Application	010-2
η vs $B(\eta)$	010-3
Hydraulic Exponent "N"	010-4
Varied Flow Function Tables	
$\eta = 0.00$ to 0.74	010-5
$\eta = 0.75$ to 0.999	010-5/1
$\eta = 1.001$ to 1.85	010-5/2
$\eta = 1.90$ to 20.0	010-5/3
Bridge Pier Losses	
Rectangular Section	
Bridge Pier Losses	

(Continued)

* Eighteenth Issue

CORPS OF ENGINEERS

HYDRAULIC DESIGN CRITERIA

VOLUME 1

TABLE OF CONTENTS (Continued)

	<u>Chart No.</u>
<u>GENERAL - 000 (Continued)</u>	
Definition	010-6
Classification of Flow Conditions	010-6/1
Class A Flow - Energy Method	010-6/2
Class B Flow - Momentum Method	010-6/3
Class B Flow - Energy Method	010-6/4
Sample Computation	010-6/5
Trash Rack Losses	010-7
Air Demand	
Regulated Outlet Works	050-1
Primary and Secondary Maxima	050-1/1
Sample Computation	050-2
Air Entrainment	
Wide Chute Flow	
Concentration (\bar{C}) vs $S/q^{1/5}$	050-3
Gate Vibration	
Resonance Diagram	060-1
Vortex Trail - Forcing Frequency	060-1/1
Forcing Frequency of Reflected Pressure Wave	060-1/2
Natural Frequency of Cable-Suspended Gate	060-1/3
Gate Bottom Vortex Trail - Sample Computation	060-1/4
Reflected Pressure Wave - Sample Computation	060-1/5
Forced Vibrations	
Constant Friction Damping	060-2
<u>SPILLWAYS - 100</u>	
Overflow Spillway Crest	**
Tangent Ordinates	111-1
Downstream Quadrant - Table of Functions	111-2
Upstream Quadrant	111-2/1
Spillway Crest	
Discharge Coefficient	
High Overflow Dams	111-3
Overflow Spillway Crest with Adjacent Concrete Sections	
Abutment Contraction Coefficient	111-3/1

(Continued)

** Changes to sheets only.

CORPS OF ENGINEERS
HYDRAULIC DESIGN CRITERIA

VOLUME 1

TABLE OF CONTENTS (Continued)

<u>SPILLWAYS - 100 (Continued)</u>	<u>Chart No.</u>
Overflow Spillway Crest with Adjacent Embankment Sections	111-3/1
Abutment Contraction Coefficient	111-3/2
Overflow Spillways	
Stage-Discharge Relation	
Uncontrolled Flow	
Unsubmerged Crests	111-3/3
Submerged Crest Coefficients	
Overflow Dams	*
Overflow Crests	111-4
Uncontrolled Flow Regimes	111-4/1*
Tailwater Effect, Example Calculation	111-4/2*
Gated Overflow Spillways	
Pier Contraction Coefficients	
High Gated Overflow Crests	
Effect of Nose Shape	111-5
Effect of Pier Length	111-6
Overflow Spillway Crests with Sloping Upstream Faces	**
Overflow Spillway Crest	
3-on-1 Upstream Face	111-7
3-on-2 Upstream Face	111-8
3-on-3 Upstream Face	111-9
n and K Curves	111-10
Overflow Spillway Crest	
Upper Nappe Profiles	
Without Piers - $H/H_d = 0.50, 1.00, \text{ and } 1.33$	111-11
Center Line of Pier Bay - $H/H_d = 0.50, 1.00, \text{ and } 1.33$	111-12
Along Piers - $H/H_d = 0.50, 1.00, \text{ and } 1.33$	111-12/1
Abutment Effects	
$H/H_d = 1.00$	111-13
$H/H_d = 1.35$	111-13/1
Upper Nappe Profiles Along Abutments	
Approach Channel and Abutment Curvature Effects	

(Continued)

- * Eighteenth Issue.
** Changes to sheets only.

CORPS OF ENGINEERS
HYDRAULIC DESIGN CRITERIA

VOLUME 1

TABLE OF CONTENTS (Continued)

<u>SPILLWAYS - 100 (Continued)</u>	<u>Chart No.</u>
$H/H_d = 1.34$	111-14
$H/H_d = 0.92, 1.14, \text{ and } 1.35$	111-14/1
High Overflow Dams	
Crest Pressures	
No Piers	111-16
Center Line of Pier Bay	111-16/1
Along Piers	111-16/2
Pressure Resultants - No Piers	111-17
Spillway Energy Loss	
Boundary Layer Development	111-18
Standard Crest Length	111-18/1
Standard Crest	
Location of Critical Point	111-18/2
Face Slope 1:0.7	111-18/3
Sample Computation	
Face Slope 1:0.7	111-18/4
Face Slope 1:0.78	111-18/5
Spillway Crests with Offset and Riser	
Crest Shapes	
Crest Location	111-19
Crest Shape	111-19/1
Crest Geometry	
Sample Computation	111-19/2
Elliptical Crest Spillway	
Coordinates	*
Coordinate Coefficients	111-20*
Crest Design	111-20/1*
Discharge Coefficients	*
Vertical Upstream Face	111-21*
1:1 Upstream Face	111-21/1*
Pier Contraction Coefficients	111-22*
Water Surface Profiles	*
Uncontrolled Crest	111-23*
Controlled Crest	
$P/H_d = 0.25$	111-23/1*
$P/H_d = 0.5$	111-23/2*

(Continued)

* Eighteenth Issue.

CORPS OF ENGINEERS
HYDRAULIC DESIGN CRITERIA

VOLUME 1

TABLE OF CONTENTS (Continued)

<u>SPILLWAYS - 100 (Continued)</u>	<u>Chart No.</u>
$P/H_d = 1.0$	111-23/3*
Spillway Crest Pressures	*
No Piers, $P/H_d = 0.25$	111-24*
No Piers, $P/H_d = 0.5$	111-24/1*
No Piers, $P/H_d = 1.0$	111-24/2*
Without Piers, $P/H_d = 3.4$	111-24/3*
With Piers, $P/H_d = 0.25$	111-24/4*
With Piers, $P/H_d = 0.5$	111-24/5*
With Piers, $P/H_d = 1.0$	111-24/6*
Along Pier, $P/H_d = 3.4$	111-24/7*
Center Line of Gate Bay, $P/H_d = 3.4$, Vertical Upstream Face	111-24/8*
Maximum Negative Pressure vs H_e/H_d	
Uncontrolled Crest ($P/H_d > 0.5$) ^d	111-24/9*
With Piers ($P/H_d > 0.5$) ^d	111-24/10*
Cavitation Safety Curves and Design	
Cavitation Safety Curves	*
No Piers	111-25*
With Piers	111-25/1*
Spillway Stilling Basins	
Hydraulic Jump	
$10 < q < 250$	112-1
$100 < q < 2500$	112-2
Velocity Distribution	112-2/1
Sequent Depth Curves for Rectangular Channel	
$3 < V_1 < 100$	112-3
$10 < V_1 < 100$	112-4
$6 < V_1 < 40$	112-5
End Sill	
Tailwater Reduction	112-5/1
High Overflow Dams	
Bucket-Type Energy Dissipator	
Roller Depth	112-6

(Continued)

* Eighteenth Issue.

CORPS OF ENGINEERS

HYDRAULIC DESIGN CRITERIA

VOLUME 1

TABLE OF CONTENTS (Continued)

<u>SPILLWAYS - 100 (Continued)</u>	<u>Chart No.</u>
Surge Height	112-6/1
Sample Computation	112-6/2
Energy Dissipators	
Flip Bucket and Toe Curve Pressures	112-7
Flip Bucket Throw Distance	112-8
Low Ogee Crest	
Discharge Coefficients	
Approach Depth Effects	122-1 [†]
Spillway Crest	
Low Ogee Crest Discharge Coefficients	
Discharge Coefficients	
Design Head	122-1/1 [†]
Overflow Spillways	
Discharge Coefficients	
Design Head	122-1/2
Low Gated Ogee Crests	
Pier Contraction Coefficients	
Effect of Approach Depth	122-2 ^{††}
Low Ogee Crests	
Crest Shape	
45-Degree Upstream Slope	**
Approach Hydraulics	122-3
Crest Shape Factors	122-3/1
Downstream Quadrant - $h^a = 0.08H_d$	122-3/2
Downstream Quadrant - $h^a = 0.12H_d$	122-3/3
Upstream Quadrant Factors	122-3/4
Upstream Quadrant Coordinates	122-3/5
Water Surface Profiles	
45-Degree Upstream Slope	
Approach Velocity	122-3/9
Upper Water - Surface Profile	
Sample Computation	122-3/10

(Continued)

** Changes to sheets only.

† Charts 122-1 and 122-1/1 were deleted in the Eighteenth Issue and superseded by Chart 111-21.

†† Chart 122-2 was deleted in the Eighteenth Issue and superseded by Chart 111-22.

CORPS OF ENGINEERS
HYDRAULIC DESIGN CRITERIA

VOLUME 1

TABLE OF CONTENTS (Continued)

<u>SPILLWAYS - 100 (Continued)</u>	<u>Chart No.</u>
Design Head Discharge Coefficient	
45-Degree Upstream Face	122-4†
Toe Curve Pressures	122-5
Spillway Chutes	
Energy-Depth Curves	
Supercritical Flow	
Energy - 20 to 44 Feet	123-2
Energy - 44 to 68 Feet	123-3
Energy - 68 to 92 Feet	123-4
Energy - 92 to 116 Feet	123-5
Sample Computation	123-6
Chute Spillways	
Computation Aids	
Hydraulic Radius-Width-Depth Curves	
Width 10 to 120 Feet	123-7
Width 100 to 1200 Feet	123-8
Velocity-Head and $V^2/2.21R^{4/3}$ Curves	123-9
Stilling Basins	
Length of Hydraulic Jump	
Continuous Slope - Length of Hydraulic Jump	124-1
Noncontinuous Slope - Jump Length on Slope	124-1/1
Morning Glory Spillways	
Deep Approach-Crest Control	
Design Discharge	140-1
Discharge Coefficient	
Design Head	140-1/1
Lower Nappe Profiles	140-1/2
Lower Nappe Surface Coordinates	
P/R \geq 2	140-1/3
P/R = 0.30	140-1/4
P/R = 0.15	140-1/5
H_s/H_d vs H_d/R	140-1/6
Crest Shape Equations	140-1/7
Spillway Design - Sample Computation	140-1/8
(Continued)	

† Chart 122-4 was deleted in the Eighteenth Issue and superseded by Charts 111-21 and 111-21/1.

CORPS OF ENGINEERS

HYDRAULIC DESIGN CRITERIA

VOLUME 1

TABLE OF CONTENTS (Continued)

	<u>Chart No.</u>
<u>OUTLET WORKS - 200</u>	
Sluice Entrances Flared on Four Sides	
Pressure-Drop Coefficients	
Elliptical Shape	211-1
Combination Elliptical Shape	211-1/1
Elliptical Shape	
Effect of Entrance Slope	211-1/2
Gate Slots	
Pressure Coefficients	
Without Downstream Offset	212-1
With Downstream Offset	212-1/1
Without Downstream Offset	
Effect of Slot Width-Depth Ratio	212-1/2
Concrete Conduits	
Intake Losses	221-1
Three-Gate-Passage Structures	221-1/1
Two- and Four-Gate-Passage Structures	221-1/2
Midtunnel Control Structure Losses	221-1/3
Earth Dam Outlet Works	
Entrance with Roof Curve Only	
Pressure-Drop Coefficients	
Upstream Face Effects	221-2
Long Elliptical Shape	221-2/1
Pressure Computation	221-2/2
Entrance with Roof Curve and Side Flare or Curve	
Entrance with Top and Sides Flared	
Pressure-Drop Coefficient	
Straight Sidewall Flare	221-3
Elliptical Top and Side Flares	221-3/1
Resistance Coefficients	
Concrete Conduits	224-1
Steel Conduits	
Smooth Interior	224-1/1
Corrugated Metal Pipe	
$\lambda = 5.3K$	224-1/2
$\lambda = 3.0K$	224-1/3
Manning's n - Full Pipe Flow	224-1/4

(Continued)

CORPS OF ENGINEERS

HYDRAULIC DESIGN CRITERIA

VOLUME 1

TABLE OF CONTENTS (Continued)

	<u>Chart No.</u>
<u>OUTLET WORKS - 200 (Continued)</u>	
Unlined Rock Tunnels	
Basic Data	224-1/5
f - Relative Roughness	224-1/6
Conduit Sections	
Hydraulic Elements	
Pressure Flow	224-2*
Straight Circular Conduit Discharge	
Discharge Coefficients	
K = 0.10-(L/D)	224-3
K = 0.20-(L/D)	224-3/1
K = 0.30-(L/D)	224-3/2
K = 0.40-(L/D)	224-3/3
K = 0.50-(L/D)	224-3/4
K = 0.10-(L/D) ^{4/3}	224-4
Circular Conduits - Friction Design Graph	224-5
Straight Circular Conduits	
Sample Discharge Computation	
(L/D)	224-6
Manning's n Method	224-7
Circular Sections	
Free-Surface Flow	
Open Channel Flow	
y _o /D vs C _k	224-8
Critical Depth and Discharge	224-9
Horseshoe Conduits	
Hydraulic Elements	224-10*
Circular Exit Portal	
Pressure Gradients	
Circular Conduits - F vs y _p /D	225-1
Bend Loss Coefficients	228-1
Miter Bends	
Single Miter	
K _B vs Reynolds Number	228-2
K _B vs Deflection Angle	228-2/1

(Continued)

* Eighteenth Issue.

CORPS OF ENGINEERS
HYDRAULIC DESIGN CRITERIA

VOLUME 1

TABLE OF CONTENTS (Continued)

	<u>Chart No.</u>
<u>OUTLET WORKS - 200 (Continued)</u>	
Pressure Flow	
Pipe Bends	228-3
Minimum Pressure	
In-Line Conical Transitions and Abrupt Transitions	*
Loss Coefficients	228-4
Abrupt Transitions	228-4/1*
Pressure Change Coefficients and Junction Box Head	
Losses for In-Line Circular Conduits	228-5
Rectangular Conduits	
Triple Bend Loss Coefficients	228-6
Two-Way Drop Inlet Structures	230-1*
Discharge Coefficient for Orifice Flow	230-1/1*
Weir Crest Length	
Sample Computation	230-1/2*

* Eighteenth Issue.

Revised 11-87

CORPS OF ENGINEERS
HYDRAULIC DESIGN CRITERIA

VOLUME 2

TABLE OF CONTENTS

	<u>Chart No.</u>
<u>GATES AND VALVES - 300</u>	
Wave Pressures on Crest Gates	
Design Assumptions	310-1
Hyperbolic Functions	310-1/1
Sample Computation	310-1/2
Tainter Gates on Spillway Crests	
Discharge Coefficients	311-1
Sample Geometric Computation	311-2
Geometric Factors	311-3
Crest Coordinates and Slope Function	311-4
Sample Discharge Computations	311-5
Effect of Gate Seat Location on Crest Pressures for $H = 1.00H_d$	311-6
Effect of Gate Seat Location on Crest Pressures for $H \sim 1.3H_d$	311-6/1
Vertical Lift Gates on Spillways	
Discharge Coefficients	312
Control Gates	
Discharge Coefficients	320-1
Vertical Lift Gates	
Hydraulic and Gravity Forces	
Definition and Application	320-2
Upthrust on Gate Bottom	320-2/1
Gate Well Water Surface	320-2/2
Sample Computation	320-2/3
Tainter Gates in Conduits	
Discharge Coefficients	320-3
Tainter Gate in Open Channels	
Discharge Coefficients	
Free Flow	
$a/R = 0.1$	320-4
$a/R = 0.5$	320-5
$a/R = 0.9$	320-6
Sample Computation	320-7
Submerged Flow	320-8
Typical Correlation	320-8/1

CORPS OF ENGINEERS

HYDRAULIC DESIGN CRITERIA

VOLUME 2

TABLE OF CONTENTS (Continued)

	<u>Chart No.</u>
<u>GATES AND VALVES - 300 (Continued)</u>	
Gate Valves	
Discharge Characteristics	
Loss Coefficients	330-1
Free Flow	330-1/1
Butterfly Valves	
Discharge and Hydraulic Torque Characteristics	
Discharge Coefficients	
Valve in Pipe	331-1
Valve in End of Pipe	331-1/1
Torque Coefficients	
Valve in Pipe	331-2
Valve in End of Pipe	331-2/1
Discharge and Torque	
Sample Computation	331-3
Howell-Bunger Valves	
Discharge Coefficients	
Four Vanes	332-1
Six Vanes	332-1/1
Flap Gates	
Head Loss Coefficients	
Submerged Flow	340-1
<u>NATURAL WATER COURSES - 400</u>	
<u>NAVIGATION DAMS - 500</u>	
Lock Culverts	
Reverse Tainter Valves	
Loss Coefficient	534-1
Minimum Bend Pressures	
Rectangular Section	534-2
Sample Computation	534-2/1
<u>ARTIFICIAL CHANNELS - 600</u>	
Trapezoidal Channels	
Open Channel Flow	

CORPS OF ENGINEERS
HYDRAULIC DESIGN CRITERIA

VOLUME 2

TABLE OF CONTENTS (Continued)

	<u>Chart No.</u>
<u>ARTIFICIAL CHANNELS - 600 (Continued)</u>	
Slope Coefficients	
0.0001 < S < 0.010	610-1
0.01 < S < 1.00	610-1/1
C_k vs Base Width	
Side Slope 1 to 1	
Base Width 0 to 200 Feet	610-2
Base Width 200 to 600 Feet	610-2/1
Base Width 0 to 50 Feet	610-2/1-1
Side Slope 1-1/2 to 1	
Base Width 0 to 200 Feet	610-2/2
Base Width 200 to 600 Feet	610-2/3
Base Width 0 to 50 Feet	610-2/3-1
Side Slope 2 to 1	
Base Width 0 to 200 Feet	610-3
Base Width 200 to 600 Feet	610-3/1
Base Width 0 to 50 Feet	610-3/1-1
Side Slope 2-1/4 to 1	
Base Width 0 to 200 Feet	610-3/2
Base Width 200 to 600 Feet	610-3/3
Base Width 0 to 50 Feet	610-3/3-1
Side Slope 2-1/2 to 1	
Base Width 0 to 200 Feet	610-3/4
Base Width 200 to 600 Feet	610-3/5
Base Width 0 to 50 Feet	610-3/5-1
Side Slope 3 to 1	
Base Width 0 to 200 Feet	610-4
Base Width 200 to 600 Feet	610-4/1
Base Width 0 to 50 Feet	610-4/1-1
Critical Depth Curves	
Side Slope 1 to 1	610-5
Side Slope 1-1/2 to 1	610-5/1
Side Slope 2 to 1	610-6
Side Slope 2-1/4 to 1	610-6/1
Side Slope 2-1/2 to 1	610-6/2
Side Slope 3 to 1	610-7

CORPS OF ENGINEERS
HYDRAULIC DESIGN CRITERIA

VOLUME 2

TABLE OF CONTENTS (Continued)

	<u>Chart No.</u>
<u>ARTIFICIAL CHANNELS - 600 (Continued)</u>	
Open Channel Flow	
Rectangular Sections	
Normal and Critical Depths	
Wide Rectangular Sections	610-8
C_k vs Base Width	
Base Widths of 0 to 200 Feet	610-9
Base Widths of 200 to 600 Feet	610-9/1
Base Width 0 to 60 Feet	610-9/1-1
Subcritical Open Channel Flow	
Drop Structures	
CIT Type	623
SAF Type	
Basic Geometry	624
Jet Impact Location	624-1
Drop Intake Structures	625-1*
Calibration Curves	625-1/1*
Typical Design	625-1/2*
Open Channel Flow	
Resistance Coefficients	631
C-n-R- K_s Relation	631-1
Sample Computation	631-2
Composite Roughness	
Effective Manning's n	631-4*
Wetted Perimeter Relation	631-4/1
Channel Curves	
Superelevation	660-1
Channel Curves with Spiral Transitions	
Rapid Flow	
Channel Curve Geometry	
Equal Spirals	660-2
Unequal Spirals	660-2/1
Spiral Curve Tables	660-2/2
Example Computation	660-2/3
Example Plan and Profile	660-2/4

* Eighteenth Issue.

CORPS OF ENGINEERS
HYDRAULIC DESIGN CRITERIA

VOLUME 2

TABLE OF CONTENTS (Continued)

	<u>Chart No.</u>
<u>SPECIAL PROBLEMS - 700</u>	
Riprap Protection	
Trapezoidal Channel - 60-Degree Bend	
Boundary Shear Distribution	703-1
Ice Thrusts on Hydraulic Structures	704
Low-Monolith Diversion	
Discharge Coefficients	711
Stone Stability	
Velocity vs Stone Diameter	712-1
Storm Drain Outlets	
Fixed Energy Dissipators	
Stilling Well	722-1
Impact Basin	722-2
Stilling Basin	722-3
Riprap Energy Dissipators	
Scour Hole Geometry	
$TW > 0.5 D$ and $< 0.5 D$	722-4
Horizontal Blanket - Length of Stone Protection	722-5
Preformed Scour Hole Geometry	722-6
D_{50} Stone Size	722-7
Surge Tanks	
Thin Plate Orifices	
Head Losses	733-1
Index	I-1