

Appendix 1

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TABLE 1
Coefficients of Runoff and Minimum Inlet Times

Land Use	Runoff Coefficient, C	Minimum Inlet Time (Min.)
Residential		
Duplex/Patio Home	0.6	15
Single Family	0.5	15
Greater than 1 acre lots	0.4	15
Commercial	0.9	10
Industrial	0.9	10
Multiple Unit Dwelling	0.8	10
Parks and Cemeteries	0.4	15
Undeveloped Open Areas	0.3	20
Shopping Centers	0.9	10
Paved Areas	0.95	10
Schools	0.6	15
Patio Homes	0.6	15

TABLE 2
Roughness Coefficients for Closed Conduits*

Material of New Construction	Recommended Roughness Coefficient, n
Concrete Pipe Storm Sewer	0.013
Corrugated Metal Pipe Culverts	0.024

Material of Existing Systems	Recommended Roughness Coefficient, n
Concrete Pipe Storm Sewer	
Fair Alignment, Ordinary Joints	0.015
Poor Alignment, Poor Joints	0.017
Concrete Pipe Culverts	0.012
Corrugated Metal Pipe Culverts	0.030

***Note: For materials other than those listed here, use manufacturer's suggestion and/or City of Arkadelphia's recommendations.**

TABLE 3
Rainfall Depths for Clark County

THESE NUMBERS ASSUME EVEN DISTRIBUTION FOR SMALL AREAS
REFER TO FIGURE 15 IN TP-40 FOR LARGE AREAS (OVER 20 SQUARE MILES)

Information Obtained From Hydro-35:

2 YEAR	5	0.5	100 YEAR	5	0.84
	15	1.05		15	1.83
	60	1.9		60	3.72

TP-40 INPUT			HYDRO-35 INPUT		
FREQUENCY	DURATION	SOURCE	RAINFALL INCHES	DURATION MINUTE	RAINFALL INCHES
2-Year	30MIN	TP-40	1.50	5	0.50
	1HR	HYDRO-35	1.90	15	1.05
	2HR	TP-40	2.30	60	1.90
	3HR	TP-40	2.60		
	6HR	TP-40	3.10		
	12HR	TP-40	3.70		
5-Year	24HR	TP-40	4.25		
	30MIN	TP-40	1.90	5	0.57
	1HR	HYDRO-35	2.31	15	1.22
	2HR	TP-40	2.90	60	2.31
	3HR	TP-40	3.25		
	6HR	TP-40	3.95		
10-Year	12HR	TP-40	4.70		
	24HR	TP-40	5.50		
	30MIN	TP-40	2.12	5	0.63
	1HR	HYDRO-35	2.61	15	1.34
	2HR	TP-40	3.35	60	2.61
	3HR	TP-40	3.70		
25-Year	6HR	TP-40	4.60		
	12HR	TP-40	5.50		
	24HR	TP-40	6.50		
	30MIN	TP-40	2.50	5	0.71
	1HR	HYDRO-35	3.05	15	1.53
	2HR	TP-40	3.80	60	3.05
50-Year	3HR	TP-40	4.40		
	6HR	TP-40	5.40		
	12HR	TP-40	6.45		
	24HR	TP-40	7.50		
	30MIN	TP-40	2.70	5	0.77
	1HR	HYDRO-35	3.38	15	1.68
100-Year	2HR	TP-40	4.30	60	3.38
	3HR	TP-40	4.90		
	6HR	TP-40	5.90		
	12HR	TP-40	7.00		
	24HR	TP-40	8.10		
	30MIN	TP-40	3.05	5	0.84
100-Year	1HR	HYDRO-35	3.72	15	1.83
	2HR	TP-40	4.80	60	3.72
	3HR	TP-40	5.40		
	6HR	TP-40	6.50		
	12HR	TP-40	7.90		
	24HR	TP-40	9.10		

TABLE 4
Roughness Coefficients for Open Channels*

Channel Description	Recommended Roughness Coefficients			Maximum Velocity (ft/s)
	Minimum	Normal	Maximum	
Minor Natural Streams				
Moderately Well Defined Channel				
Grass and Weeds, Little Brush	0.025	0.030	0.033	8
Dense Weeds, Little Brush	0.030	0.035	0.040	8
Weeds, Light Brush on Banks	0.030	0.035	0.040	8
Weeds, Heavy Brush on Banks	0.035	0.050	0.060	8
Weeds, Dense Willow on Banks	0.040	0.060	0.080	8
Irregular Channel With Pools and Meanders				
Grass and Weeds, Little Brush	0.030	0.036	0.042	8
Dense Weeds, Little Brush	0.036	0.042	0.048	8
Weeds, Light Brush on Banks	0.036	0.042	0.048	8
Weeds, Heavy Brush on Banks	0.042	0.060	0.072	8
Weeds, Dense Willow on Banks	0.048	0.072	0.096	8
Floodplain, Pasture				
Short Grass, No Brush	0.030	0.035	0.040	8
Tall Grass, No Brush	0.035	0.040	0.050	8
Floodplain, Cultivated				
No Crops	0.030	0.035	0.040	8
Mature Crops	0.035	0.045	0.050	8
Floodplain, Uncleared				
Heavy Weeds, Light Brush	0.050	0.060	0.070	8
Medium to Dense Brush	0.070	0.100	0.160	8
Trees with Flood Stage below Branches	0.080	0.100	0.120	8
Major Natural Streams				
<i>The roughness coefficient is less than that for minor streams of similar description because banks offer less effective resistance.</i>				
Moderately Well Defined Channel	0.025		0.060	8
Irregular Channel	0.035		0.100	8
Unlined Vegetated Channels				
Mowed Grass, Clay Soil	0.025	0.030	0.035	8
Mowed Grass, Sandy Soil	0.025	0.030	0.035	6
Unlined Non-Vegetated Channels				
Clean Gravel Section	0.022	0.025	0.030	8
Shale	0.025	0.030	0.035	10
Smooth Rock	0.025	0.030	0.035	15
Earth Lined, Sandy	0.028	0.035	0.040	6
Earth Lined, Clay	0.028	0.035	0.040	8
Lined Channels				
Smooth Finished Concrete	0.013	0.015	0.020	15
Riprap (rubble)	0.030	0.040	0.050	12
Gabion	0.028	0.032	0.035	15
Pavement				
Concrete	-	0.015	-	-
Asphalt	-	0.017	-	-

* Note: Deviations from these values must be approved by the City of Arkadelphia.

TABLE 5A
Velocity Head Loss Coefficients for Closed Conduits

Description of Conditions	Kj
Inlet on Main Line	0.5
Inlet on Main Line with Branch Lateral	0.25
Manhole on Main Line with bend at:	
90 degrees	0.25
60 degrees	0.35
45 degrees	0.5
22.5 degrees	0.95
Wye Connection or Cut In	
60 degrees	0.6
45 degrees	0.75
22.5 degrees	0.95
Inlet or Manhole at the Beginning of Line	1.25
Conduit Curves for 90 degrees*	
Curve Radius	
2 to 8 times the diameter **	0.4
8 to 20 times the diameter	0.25
Greater than 20 times the diameter	0
Bends where the radius is equal to the Diameter	
90 degree bend	0.05
60 degree bend	0.43
45 degree bend	0.35
22.5 degree bend	0.2

The values of the coefficient "Kj" for determining the loss of head due to obstructions in pipes are shown in Table 6-B and the coefficients are used in the following equation to calculate the head loss at the obstruction:

$$H_j = K_j (V^2/2 \cdot g)$$

* Where deflection other than 90 degrees are used, the 90 degree deflection coefficient can be used with the following percentage factors:

60 degree bend = 0.85

45 degree bend = 0.70

22.5 degree bend = 0.40

**The diameter is the inside diameter of the pipe.

TABLE 5B
Head Loss Coefficients Due to Sudden
Enlargements and Contractions

D2/D1*	Sudden Enlargements, K_j	Sudden Contractions, K_j
1.2	0.1	0.08
1.4	0.23	0.18
1.6	0.35	0.25
1.8	0.44	0.33
2	0.52	0.36
2.5	0.65	0.4
3	0.72	0.42
4	0.8	0.44
5	0.84	0.45
10	0.89	0.46
> then 10	0.91	0.47

***D2/D1 = Ratio of larger to smaller diameter**

TABLE 6
Velocity Requirements for Closed Conduits*

Material of New Construction	Velocity	
	Minimum	Maximum
Storm Sewers	2.500	15
Inlet Laterals	2.500	15
Culverts	2.500	10

**For velocity requirements in Open Channels see Table 4. Storm Sewers shall discharge into open channels at a maximum velocity of 6 feet per second.*

TABLE 7
Design Criteria for the Design of Roads, Culverts, and Channels*

Road Classification	Design Return Period**	Design Spreads
Major Thoroughfare		
Principal Arterial	10-Year	Two Lanes Open Ea. Direction
	100-Year	Top of Curb
Minor Arterial	10-Year	One Lane Open Ea. Direction
	100-Year	Top of Curb
Collector	10-Year	Allow 1 Lane Open
	100-Year	Top of Curb
Local	10-Year	Top of Curb
	100-Year	Contained within the Right of Way
Rural Road w/ Bar Ditches	10-Year	One Foot Below Pavement
	100-Year	Contained within the Right of Way

Other Drainage Structures	Design Return Period
Enclosed Storm Sewer System	25-Year
Culvert or Bridge Along a Creek, River, or other Watercourse	25-Year
Culvert or Bridge not Located on a Creek River or other Watercourse	10-Year
Channel Improvements	25-Year***

**Note: The City Engineer may reserve the right to require more stringent requirements depending on the location of a specific project. All deviations from what is shown must be approved by the City of Arkadelphia.*

*** All design periods are based on Fully Urbanized conditions. Flows for channels and channel crossings may be obtained from the City of Arkadelphia.*

****Note: For Channel Improvements the 25-year storm should be contained within the channel. Adjacent structures and lots must be a minimum of one foot above the 100-year fully urbanized floodplain.*