CITY OF SALINA, KANSAS

ENGINEERING & UTILITIES DEPARTMENT

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DESIGN CRITERIA

STORM DRAINAGE SYSTEMS

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Revised
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A. INTRODUCTION:

The purpose of compiling criteria for standard procedures in storm sewer design is to develop improved methods of planning and designing storm sewer systems. It covers the design procedures to be followed and the reference information to be furnished by a licensed professional engineer responsible for the design of the storm sewer system.

The City of Salina shall not approve any plat of a subdivision which does not make adequate provisions for storm water runoff control. The applicant shall be required to submit a drainage report prepared by a licensed professional engineer which examines the effects of the proposed subdivision on all upstream and downstream drainage conditions. The scope of this report shall be determined by the City Engineer. The drainage report shall assume the ultimate development of the entire drainage basin based upon the current land use plan and the current and proposed zoning of the land within the drainage basin.

The city may require the developer of the proposed subdivision to construct or cause to be constructed all necessary storm drainage systems, designed in accordance with the design criteria established by the City Engineer, prior to the issuance of any building permit. These design criteria are not expected to cover all conceivable situations to be encountered in engineering design. The design criteria do not consist of rigid or inflexible rules, but allow for minor deviations depending upon individual design situations.

No drainage project responsibility begins or ends within the boundary of a particular subdivision. Each proposed solution to a drainage problem must be reviewed to determine its effect upon adjacent lands and general conformance with established storm drainage patterns and systems. Drainage problems can not be compounded by transferring drainage problems to another location.

B. GENERAL:

B.1 STORMWATER - Stormwater shall generally be carried in storm sewer systems on the basis of criteria established in this section and subject to final determination and approval of the City Engineer.

B.2 PROTECTION - Storm sewer systems shall be designed to prevent flooding of improvements by storms having the return period designated in Section E.3.

B.3 STORM SEWER SYSTEMS - Systems shall be designed to protect against flooding of property of all classes and maintain the required level of service for public facilities. Storm sewer systems shall be designed as a coordinated unit and may include any or all of the following elements:

a. Enclosed storm sewers and appurtenances
b. Open channels

c. Swales on property lines and/or rear lot lines
d. Paved streets with curbs and gutters

B.3.1 ENCLOSED STORM SEWERS - Enclosed storm sewers shall be used to collect and convey drainage on, across, and through public right-of-way. Outfall drains shall extend at least 60 feet to the rear of the front building line or 20 feet past the back line of the structure, whichever is greater.

B.3.2 OPEN CHANNELS - Open channels are acceptable only to carry stormwater runoff from tributary areas exceeding 100 acres, or from smaller tributary areas otherwise requiring an enclosed storm sewer pipe 48 inches in diameter or larger, except enclosed drainage structures shall be provided where open channels cross public street right-of-way.

B.3.3 ROAD SIDE DITCHES - Road side ditches are generally not acceptable and may be used to convey drainage along public street right-of-way only when designated by the City Engineer. Culverts and appurtenant drainage facilities shall be designed to permit their incorporation into a future enclosed storm sewer system when possible. Ditches shall be designed to meet the requirements for open channels.

B.4 VELOCITY - Discharge velocity shall be controlled to prevent both erosion and siltation at and immediately downstream from the point of discharge. Energy dissipating structures shall be used if required.

C. DESIGN PROCEDURE:

C.1 MAPS - Prints showing the watershed area, recorded plats, survey maps or other plans which are available showing the design tributary area shall be obtained.

C.2 SURVEYS - Check and confirm survey reference data with recorded information.

C.3 UTILITIES - The location of all utility lines existing and proposed from files and other information supplied by utility companies and City records should be checked.

C.4 EXISTING INFORMATION - Determine the ridge lines of the tributary area and establish the general routing of the proposed sewer line. Check connecting storm sewer lines, appurtenances, street grades and all other information pertaining to the location of the proposed sewer.

C.5 PRELIMINARY LAYOUT - Prepare the preliminary layout and grades. The drainage pattern must be compatible with the existing pattern established in the area.

C.6 ULTIMATE DEVELOPMENT - Compute the estimated ultimate density and impervious surfaces of the area. Information may be obtained from the City Engineer's office or the Planning and Community Development Department.

C.7 FIELD CHECK - Verify the preliminary design by field checking of the watershed area, critical connections, crossings, slopes, etc.

C.8 RUNOFF - Establish and indicate curb grades, outline the runoff area, and indicate cubic feet per second by increment at each point of interception.

C. 9 CURB CAPACITIES - Calculate curb capacities for each side of the street interdependently. Differences in curb elevations, off center crowns, etc., must be taken into consideration.

C.10 INLETS - When calculations indicate that pavement encroachment is exceeded at a point no further allowance shall be made for flow beyond that point and inlets shall be used to intercept flow at that point. Paved gutters or flumes may be used to intercept flow and drained to an outfall on approval of the Engineer.

C.11 INLET AND PIPE CAPACITY - Calculate capacities for inlets and size pipes.

C.12 ENCROACHMENT - The maximum allowable pavement encroachment of stormwater during the design storm shall be as follows:

Street Classification	Maximum Encroachment
Local	Flow may not exceed curb height.
Collector	One 8' lane must be clear.
Arterial	One 8' lane in each direction must be clear.

An additional requirement to the above encroachment limits is that the runoff from the 100-year (1% return period) frequency storm must be retained within the right-of-way of the public street.

C.13 HYDRAULICS - Calculate and show hydraulics of pipe inlets. Calculate velocity head and hydraulic profiles of flows exceeding a velocity of 15 feet per second.

D. COEFFICIENTS OF FRICTION

The coefficients of friction allowed for the various kinds of storm sewer pipe are as follows:

Portland Cement Concrete	n = 0.013
Corrugated Metal	n = 0.021
Corrugated Metal with Paved Invert	n = 0.019
Smooth Flow Corrugated Metal	n = 0.012

E. RUNOFF CALCULATIONS AND CRITERIA

The rational method of calculating stormwater quantities, Q = CIA, shall be used with the

following definitions of terms and arbitrary values:

E.1 Q is the quantity of runoff in cubic feet per second and is used as a basis for design of the storm drainage system.

E.2 C is the coefficient of runoff and shall have the following values where applicable:

E.2.1

Description of Area	Runoff Coefficients
1. Residential:	
Single-family areas	0.40 to 0.60
Multi-units, detached	0.50 to 0.60
Multi-units, attached	0.60 to 0.80
Residential (suburban - 1 acre of land or more)	0.30 to 0.40
2. Commercial:	
Downtown Area	0.85 to 0.95
Shopping and Office areas	0.60 to 0.80
3. Industrial:	
Light areas	0.50 to 0.80
Heavy areas	0.60 to 0.90
4. Other:	
Churches and Schools	0.70 to 0.90
Playgrounds	0.20 to 0.40
Parks and Cemeteries	0.20 to 0.35
Agricultural	0.10 to 0.30

E.2.2 Where average area calculations are submitted, the following coefficients of runoff shall be used:

Asphalt Surfaces		0.95
Concrete Surfaces		0.95
Gravel Surfaces		0.80
Roof areas		1.00
Lawns – Flat	2%	0.20
Average	2% to 7%	0.25
Steep	7% and up	0.30

E.3. I is intensity of rainfall in inches per hour and shall be determined for the yearly (return period) frequency specified below and as specified from Fig. A & B attached to these criteria:

E.3.1 10-year (10% return period) - Enclosed drainage structures in residential areas; original conditions on undeveloped areas being considered for re-zoning, platting; etc.

E.3.2 25-year (4% return period) - Enclosed drainage structures in commercial areas; detention ponds; arterial street culverts; and open channels.

E.3.3 The duration time or time of concentration to be used in the Rational Formula shall be estimated by the designer and shall include time for overland flow based on the formula

$$T_C = \frac{K_O L^{0.37}}{S^{0.2}}$$

and/or time for channel flow based on the formula

$$T_C = K_C \, (L^2/S)^{0.385}$$

K_O = Overland Flow Coefficient

TYPE OF SURFACE	K_O
Pavement	0.372
Commercial	0.445
Residential	0.511
Bare Soil	0.604
Cultivated	0.775
Pasture	1.040

K_C = Channel Flow Coefficient

TYPE OF NATURAL CHANNEL	K_C
Straight-Clean	0.00592
Average	0.00835
Meandering or Pooling	0.01020
V-Ditch	0.01252

L = Length of drainage basin or channel expressed in feet.

S = Slope of drainage basin or channel expressed in feet/feet.

Time of concentration equals the inlet time plus the time for water to flow down the pipe or channel to the point at which the peak flow is to be determined. The inlet time shall be computed taking into account the topography, shape, and surface characteristics of the contributing area. Use the maximum rainfall intensity for a time of concentration equal to 15 minutes for all computed times of concentration less than 15 minutes.

E.4 A is the area in acres contributing to the drainage system. All upstream tributary areas are to

be considered as fully developed as zoned at the time of design.

F. PIPE SIZING:

F.1 MANNING FORMULA - Pipe sizes in integrated underground systems will normally be determined in accordance with the Manning Formula,

$$V = \frac{1.49R^{(2/3)}S^{(1/2)}}{n}$$

The value of n in the Manning Formula shall be as designated under Section D above. The exception will be in cases where slopes are above the critical. Pipe sizing shall then be determined by entrance control. Head shall be considered up to a point where inundation will cause damage to properties.

F.2 MINIMUM PIPE SIZE - The minimum size storm sewer shall be 18 inches in diameter.

F.3 VELOCITY - All storm drainage systems shall be designed so as to maintain a minimum velocity of flow of 3 feet per second and a maximum velocity of 15 feet per second when flowing full.

F.4 VELOCITY HEAD - Large quantities or masses of water flowing at a high rate of speed contain a large amount of kinetic energy defined as velocity head ($V^2/2g$). Any change in cross section, restrictions in pipes or inlets shall be considered energy losses and shall be taken into consideration in the design of the system.

G. LOCATION:

Enclosed storm drainage conduits shall be located in the street right-of-way or easements.

H. DEPTH:

All enclosed storm drainage conduits shall have a minimum cover of 18 inches where practical. Cover may be decreased to avoid conflicts. Special bedding or protection shall be required where cover is decreased below 18 inches.

I. INLETS:

I.1 GENERAL - Contain all flow within maximum encroachment limits as designated in Section C.12 during the following design storms:

10-year - Residential Areas
25-year - Commercial/Industrial Areas

I.2 SPECIAL FEATURES - Inlets located on streets with grades in excess of 3% shall include

curb openings and gutter grate openings. Gutter grates must be of the curved vane type to minimize hazards to pedestrians and bicycles.

J. OPEN CHANNELS:

J.1 GENERAL - Open channels shall be sized to carry design rates of flow without significant damage or erosion to the channel. Channels shall be sloped to protect the public from injury.

J.2 CONNECTIONS - Pipe culverts, box culverts, and other structures entering channels shall not project into the normal waterway area.

J.3 VELOCITY - Channel design shall include lining or treatment of the invert and sides as required to minimize erosion. Channel inverts and sides shall be lined to a height 1.0 foot above the hydraulic grade line produced by a flow rate of 100 percent of the peak design rate of 25-year storms in accordance with the following table:

Mean Flow Velocity	Type of Lining
≤ 3 ft/sec	Seeded
> 3 to 6 ft/sec	Sod
> 6 to 15 ft/sec	Riprap or concrete paved
> 15 ft/sec	Concrete paved

Lining materials having equivalent erosion control properties to those shown in the foregoing table may be used in lieu thereof.

J.4 LOCATION - Open channels shall be located in public right-of-way and not easements.

J.5 CAPACITY - Open channels shall be sized to carry design flow rates with 1.0 foot of freeboard.

J.6 SECTIONS - Channel sections shall be compatible with the type of lining and maintenance practice to be used. Side slopes shall not be steeper than 2 horizontal to 1 vertical. Channels lined with sod, grass, or other vegetative ground cover shall not have slopes steeper than 4 horizontal to 1 vertical and shall have a minimum bottom width of eight feet.

J.7 CHECK DAMS FOR WASH CHECKS - Check dams may be used to control flow velocity in open channels. Check dams shall be designed to prevent flow by-pass by undercutting or erosion around the ends. Adequate paving or riprap shall be provided at the down stream toe of check dams to prevent erosion or less of foundation support by undercutting. Wood may not be used for check dam construction.

J.8 NATURAL CHANNELS - Natural channels of adequate capacity and having stable banks and invert may be used without modification.

K. DETENTION STORAGE:

K.1 GENERAL - Storm runoff detention is considered a viable method to reduce drainage costs. Temporarily detaining a specified volume of runoff can significantly reduce downstream flood hazards. The main purpose of a detention facility is to store the excess storm runoff associated with increased basin imperviousness and discharge this excess at a rate similar to the rate experienced from the basin without development.

Excess storm runoff shall be judged in comparison to the site in its pre-developed condition and shall include all increases in stormwater resulting from any of the following:

1. An increase in the impervious surface of the site, including all additions of buildings, roads and parking lots.

2. Changes in soil absorption caused by compaction during development.

3. Modifications in contours, including the filling or draining of small depressional areas, alterations of drainageways, or regrading of slopes.

4. Destruction of woodlands.

K.2 PERFORMANCE CRITERIA

K.2.1 The design storm shall be a storm of 24-hour duration and having the return periods set forth in Section E.

K.2.2 Detention storage areas shall have adequate capacity to contain maximum required volume of tributary storm drainage runoff with 1.0 foot of freeboard. Adequate access provisions and allowances shall be made for the accumulation and removal of silt. Detention storage areas shall have adequate capacity to contain all the additional stormwater runoff generated by the proposed ultimate development during the design storm.

K.2.3 Outlet works shall be designed to limit peak outflow rates from detention storage areas to or below peak flow rates that would have occurred prior to the proposed ultimate development of the tributary area.

1. Outlet works shall not include any mechanical or electrical components that require attendance or control during operation.

2. Size and hydraulic characteristics of the outlet works shall be such that all water in detention storage can be released to the downstream stormwater system within 24 hours of the end of the design storm.

3. The outlet works shall be designed with the capability of totally manually restricting the release of the required detention storage into downstream stormwater systems during the design storm.

K.2.4 Emergency spillways shall be provided to permit safe passage of water from storms producing runoff in excess of design storm.

K.2.5 The slopes of the detention storage areas shall not be steeper than 4 horizontal to 1 vertical. The minimum bottom width shall be eight feet and the minimum width of the top of the dike shall be eight feet.

K.2.6 Provide a minimum of eight feet separation between the fill or cut slopes and the property boundaries.

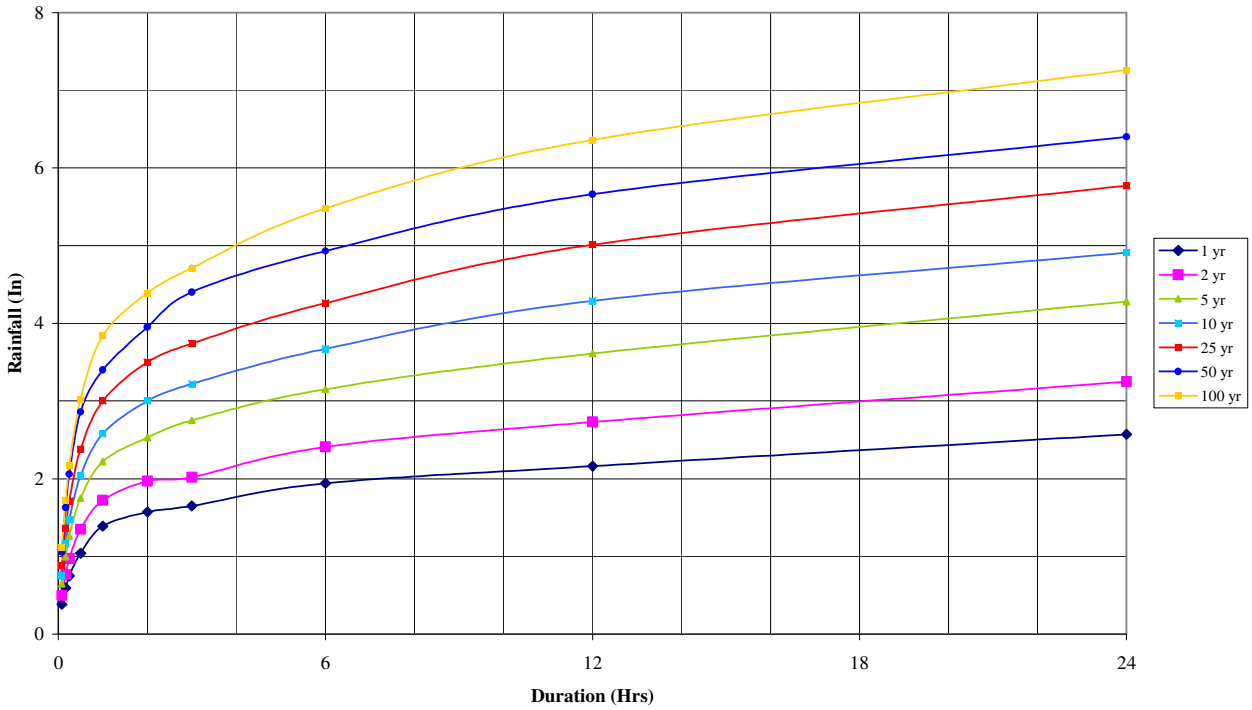
K.2.7 The detention storage area shall be seeded with a combination of a minimum of two types of short-rooted grasses approved for this area.

K.2.8 The cross-slope of the detention storage area to the detention swale or channel shall not be less than 2%. These bottom swales or channels shall be constructed of concrete to provide positive drainage.

K.3 LAND REQUIREMENTS - Permanent easements for the detention storage of stormwater runoff shall be granted over all lands, structures, and facilities to be used for the detention and conveyance of storm drainage. Easements shall include all necessary provisions and land necessary for the City's right-of-entry for purposes of inspection and/or maintenance. All instruments for easements shall be subject to the approval of the City Engineer.

K.4 MAINTENANCE - Provisions acceptable to the City Engineer shall be made for perpetual maintenance of detention storage facilities, outlet works, and appurtenances.

Figure "A"
Rainfall/Frequency/Duration Curve for Salina, KS
Data from U.S. Dept. of CommerceT.P. #40



Rainfall Intensities (In/Hr)							
Duration (Min)	*1 Yr*	*2 Yr*	*5 Yr*	*10 Yr*	*25 Yr*	*50 Yr*	*100 Yr*
15	3.00	3.89	5.04	5.88	6.85	8.24	8.70
16	2.91	3.79	4.91	5.72	6.68	8.01	8.48
17	2.84	3.69	4.78	5.57	6.50	7.82	8.25
18	2.76	3.58	4.65	5.41	6.32	7.60	8.03
19	2.69	3.49	4.52	5.27	6.15	7.40	7.81
20	2.61	3.40	4.40	5.13	5.98	7.20	7.59
21	2.54	3.31	4.28	5.00	5.82	7.01	7.39
22	2.48	3.22	4.17	4.86	5.67	6.83	7.20
23	2.41	3.14	4.07	4.74	5.53	6.65	7.03
24	2.35	3.06	3.97	4.63	5.40	6.50	6.85
25	2.30	2.99	3.87	4.52	5.27	6.35	6.69
26	2.25	2.93	3.79	4.42	5.15	6.20	6.55
27	2.20	2.86	3.71	4.32	5.05	6.07	6.40
28	2.16	2.81	3.64	4.24	4.95	5.95	6.27
29	2.10	2.75	3.56	4.16	4.85	5.83	6.15
30	2.08	2.70	3.50	4.08	4.76	5.72	6.04
31	2.04	2.65	3.44	4.01	4.68	5.61	5.94
32	2.01	2.61	3.37	3.94	4.59	5.50	5.83
33	1.98	2.56	3.32	3.87	4.51	5.39	5.73
34	1.94	2.52	3.26	3.79	4.42	5.29	5.63
35	1.91	2.47	3.20	3.73	4.35	5.17	5.52
36	1.88	2.42	3.14	3.66	4.26	5.07	5.42
37	1.85	2.38	3.08	3.60	4.19	4.98	5.32
38	1.82	2.34	3.03	3.53	4.11	4.88	5.23
39	1.80	2.30	2.97	3.48	4.05	4.78	5.14
40	1.77	2.26	2.93	3.41	3.97	4.69	5.06
41	1.74	2.23	2.88	3.35	3.90	4.60	4.98
42	1.71	2.19	2.83	3.30	3.84	4.51	4.89
43	1.70	2.15	2.78	3.24	3.78	4.42	4.82
44	1.67	2.12	2.74	3.20	3.71	4.34	4.75
45	1.65	2.09	2.70	3.15	3.66	4.27	4.68
46	1.63	2.06	2.66	3.10	3.60	4.18	4.60
47	1.60	2.03	2.62	3.05	3.55	4.11	4.53
48	1.59	2.00	2.58	3.01	3.50	4.04	4.47
49	1.57	1.97	2.55	2.96	3.45	3.98	4.40
50	1.55	1.95	2.52	2.92	3.40	3.92	4.34
51	1.53	1.92	2.48	2.88	3.35	3.85	4.29
52	1.51	1.90	2.45	2.85	3.31	3.80	4.23
53	1.50	1.87	2.42	2.81	3.26	3.74	4.18
54	1.49	1.85	2.38	2.77	3.22	3.68	4.12
55	1.47	1.82	2.35	2.74	3.18	3.63	4.07
56	1.45	1.80	2.33	2.70	3.14	3.57	4.02
57	1.43	1.78	2.30	2.67	3.11	3.53	3.97
58	1.42	1.76	2.27	2.64	3.07	3.49	3.93
59	1.41	1.74	2.25	2.61	3.03	3.44	3.89
60	1.39	1.72	2.22	2.58	3.00	3.40	3.84

Figure "B"

Intensity/Frequency/Duration for Salina, Kansas

Data from T.P. #40 US Dept of Commerce