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SECTION 0500 STORMWATER SYSTEMS

0501 GENERAL REQUIREMENTS

0501.1 Stormwater Master Plan

The stormwater drainage systems shall comply with the provisions of the Stormwater Master Drainage Plan.

0501.2 ODEQ Permitting

All ODEQ standards and permits shall be followed.

0501.3 Alignment Surveys

Alignment surveys for street projects shall be performed as specified in Section 0110, General; Paragraph 0116.3, Alignment Surveys.

0501.4 Maintenance Bond

The construction contractor shall post a maintenance bond or Irrevocable Letter of Credit in an amount equal to 100 percent of the determined amount of construction costs for a two-year period after completion and acceptance of all improvements. The bond shall be written wherein the City is the grantee.

0501.5 City of Owasso Review

The City of Owasso reserves the right to direct changes in stormwater alignment, grade, and appurtenance placements. Design calculations shall be presented within an Engineering Report for review by the Engineer.

0501.6 Plan Requirements

A. Construction plans shall comply with Subsection 0117, Engineering Design Criteria.

B. Plans shall include the following:

1. Profiles with elevations for all storm sewer lines, culverts, swales and any other means of conveying storm water.

2. Direction of flow both pre- and post-development.

3. Building pad elevations

0501.7 Property Owner/Developer Responsibilities

It shall be the responsibility of all owners of property within the City, whether undeveloped, developed, or undergoing development to maintain any and all stormwater facilities. The following requirements apply to all owners throughout the transfers/sales of property and particularly to the Developer and his contractor during construction of his/her development.

A. Mow and provide minor maintenance of drainage channels and their slopes for that portion of the channel lying within their property line.

B. Keep clear all drainage channels within the boundaries of their properties in accordance with the requirements of this article.

C. Control all storm water runoff and drainage from points and surfaces on the property.

D. Prevent any and all drainage interferences, obstructions, blockages, or other adverse effects upon drainage, into, through, or out of the property.

E. Take no action which will alter or otherwise change designed and installed storm water management control systems and take no action on existing property that shall adversely affect stormwater runoff in any manner contrary to the provisions of this Section, whether temporary, permanent, or a combination thereof.

F. The City may require improvements and/or drainage easements beyond subdivision boundaries, development, or property improvement for the following reasons:

1. Facilitate flow of stormwater from or through the property,

2. Avoid damage from changed runoff conditions,

3. Provide continuous improvement of the overall storm drainage system, and

4. Accommodate all drainage conditions or requirements.

G. Where stormwater runoff flows require the logical extension of any street or its associated drainage in order to prevent flooding, ponding, or uncontrolled runoff, the extension shall be provided by the Developer.

H. During construction: Developers, property owners, builders, and Contractors shall be required to keep streets, gutters, inlets, drainage pipes, swales, ditches, drainage channels, emergency drainage swales and all drainage devices and structures clean and free from debris, sedimentation, soil, and any deleterious materials. Any failure to meet this requirement shall, upon sufficient notice and failure to immediately correct the notified condition, constitute grounds for initiation of enforcement action, including, but not limited to, stopping all work until correction is completed.

I. Developers, builders, property owners, or their legal agents, upon receipt of notice by the City of Owasso that repair or maintenance is required within a channel lying within their property, shall be responsible for effecting such repair or maintenance within the time specified, or the City shall have repair and maintenance performed at the expense of the property owner unless it can be proven that the damage was caused by another entity.

0501.8 City of Owasso Responsibilities

It shall be the responsibility of the City of Owasso to:

A. Following acceptance of infrastructure and expiration of maintenance bonds, repair and maintain drainage channels and their slopes when located within or upon easements or rights-of-way dedicated to the City of Owasso.

B. Develop and implement standards and specifications required to clearly and accurately interpret the physical requirements of this section.

C. Make such necessary improvements of primary and secondary drainage channels that cannot or will not be improved through private development.

D. Improve and maintain floodway areas and areas between the floodway and limits of the 100-year floodplain (flood fringe) that are dedicated public areas, rights-of-way, parklands, or public-owned buildings or developments.

E. Improve and maintain all public-owned drainage channels or systems outside the flood fringe area.

0501.9 Homeowners Association

Covenants (or Deed of Dedication Restrictions) developed during the subdivision platting process must provide for the formation of a homeowners (or commercial owners) association. The responsibilities for stormwater management attached to the Developer during construction of infrastructure must transfer to the association. These responsibilities pertain to maintenance of stormwater features within commons areas and those not located within a dedicated utility or drainage easement.

0502 EASEMENTS

0502.1 Overland Flows

A. All restricted drainage easements will be shown detailed on the construction plans and final plat, as well as described in the conditions and restrictions of the plat.

B. No structures or obstructions of any form shall be allowed on drainage easements.

C. The conditions and restrictions of the plat shall designate the responsible party for maintenance of the area within the drainage easement.

D. Adequate right-of-way must be provided for access and maintenance to the drainage easement.

0502.2 Floodplain

The City may accept dedication of the entire floodway and/or floodplain area for an unimproved channel. Floodway development must be in accordance with a Conditional Letter of Map Revision (CLOMR) from FEMA. Floodplain development must be in accordance with a Flood Development Permit issued by the floodplain manager.

0502.3 Storm Sewer

The minimum easement width shall be 15 feet or the outside diameter of pipe plus 10 feet, whichever is greater, and the pipe shall be laid in the center of easement.

0503 DRAINAGE SYSTEM REQUIREMENTS

0503.1 Review by the City of Owasso

All stormwater designs and construction plans shall be approved by the Engineer.

0503.2 Classifications

Stormwater drainage systems, both public and private, may consist of storm sewers (closed conduits); improved channels constructed in conformity with adopted City standards; unimproved drainageways left in their natural condition; the areas covered by restricted drainage easements for the purpose of providing overland flow; and appurtenances to the above including the street system, curbs and gutters, detention/retention ponds and lakes, underground detention structures, inlets, manholes, junction boxes, headwalls, dissipaters, and culverts.

0503.3 System Design

A. The stormwater drainage system shall be designed to receive and pass the runoff from a 100-year frequency rainstorm within dedicated easements or public rights-of-way under full urbanization. Full urbanization is defined as the total development in an area that is anticipated. The entire flow shall be confined within the said stormwater drainage system.

B. Drainage areas in acres, runoff coefficients, peak flows from 5-year, 10-year and 100-year frequency rainstorms, time of concentration, and capacity of each inlet and pipe shall be summarized and tabulated on the plans. This summary table shall also be a part of the drainage calculations.

C. The stormwater collection system shall be designed to either:

   a. As a minimum, pass the 5-year frequency runoff in a pipe network with overland flow capacities (within dedicated easements or rights-of-way) so that the combination of the two will pass the 100-year runoff under fully urbanized condition OR

   b. Pass the entire 100-year runoff in the pipe network. The network inlets must be designed to convey the runoff even in the event of blockage or bypass.

0503.4 Overland Flow

The overland flow portion of the collector system shall be confined to dedicated rights-of-way or restricted drainage easements to assure that stormwater can pass through the development without inundating the lowest level of any building, dwelling, or structure. Restricted drainage easements shall be shown on the plat.

0504 RAINFALL

0504.1 Introduction

Presented in this section are the design rainfall data which shall be used for runoff hydrograph calculations. All hydrological analyses for the City of Owasso shall utilize the rainfall data presented herein for calculation of storm runoff.

0504.2 Total Rainfall

Rainfall data to be used for projects in the City of Owasso are contained below. US Weather Bureau Technical Paper No. 40, Rainfall Frequency Atlas of the United States is the basis for cumulative rainfall data of storm durations greater than one hour. The National Oceanic and Atmospheric Administration (NOAA) Technical Memorandum NWS HYDRO-35 is the basis for cumulative rainfall data of storm durations from 5 to 60 minutes.

Total Rainfall Depth – Inches
Frequency (Return Period)

Duration	1-Year	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year	500-Year
5-minute	0.40	0.48	0.56	0.62	0.72	0.79	0.86	1.01
10-minute	0.71	0.84	0.99	1.11	1.27	1.41	1.54	1.83
15-minute	0.84	1.01	1.20	1.34	1.54	1.70	1.86	2.23
30-minute	1.14	1.40	1.73	1.96	2.29	2.55	2.81	3.39
1-hour	1.44	1.81	2.28	2.60	3.07	3.44	3.80	4.58
2-hour	1.70	2.13	2.80	3.30	3.85	4.44	5.00	6.12
3-hour	1.87	2.28	3.13	3.63	4.25	4.83	5.43	6.60
6-hour	2.19	2.71	3.64	4.30	5.08	5.71	6.40	7.80
12-hour	2.63	3.23	4.31	5.10	6.00	6.71	7.55	9.20
24-hour	3.00	3.75	5.15	5.88	7.00	7.78	8.75	10.68

Source: U.S. Weather Bureau Technical Paper No. 40 and HYDRO-35

0505 RUNOFF

0505.1 Approved Methods

A. The following table contains methods of runoff analysis that may be used for the design of components of the storm drainage system as applicable:

Runoff Methods

	Peak Q	Volume Calc	Maximum Drainage Area, AC
SCS Method	Yes	Yes	2,000
Rational Method	Yes	No	60

B. The SCS method of runoff analysis is preferable for use in the City of Owasso.

0505.2 Rational Method

A. Formula: The Rational Method is based on the formula: Q=CIA

"Q" the maximum rate of runoff in cubic feet per second.
"C" runoff coefficient of the area.
"I" the average intensity of rainfall in inches per hour for a duration equal to the time of concentration (T_c).
"T_c" the time of concentration is the time required for water to flow from the most remote point of the basin to the point being investigated and to reach a steady state condition.
"A" The contributing watershed area in acres.

B. Time of concentration: In lieu of the foregoing, formulas may be used as contained in the ODOT Roadway Design Manual, Section 15.3.2.1.

1. One of the basic assumptions underlying the Rational Method is that runoff is a function of the average rainfall rate during the time required for water to flow from the most remote part of the drainage area to the point under consideration.

2. The time of concentration consists of overland flow time, T_o plus the time of travel, T_f, in the storm sewer, paved gutter, roadside drainage ditch, or drainage channel. For non-urban areas, the time of concentration consists of an overland flow time, T_o, plus the time of travel in a combined form, such as a small swale, channel, or drainage. The latter portion, T_f, of the time of concentration can be estimated from the hydraulic properties of the storm sewer, gutter, swale, ditch, or drainage. Overland flow time, on the other hand, will vary with surface slope, surface cover, and distance of surface flow. The infiltration rate of the soil, the presence of depression storage areas, and the amount of antecedent rainfall will also affect the overland flow time, since the rainfall must first overcome these losses before a steady state runoff condition will be achieved. Thus, the time of concentration can be calculated using the following equation:

$T_c = T_o + T_f$ In which:

T_c = time of concentration (minutes)
T_o = initial, or overland flow time (minutes)
T_f = travel time in the ditch, channel, gutter, storm sewer, etc. (minutes)
Minimum time of concentration, T_c, shall be 5 minutes.

3. The overland flow time, T_o, in non-urbanized watersheds may be calculated as follows: $T_o = 1.8\ (1.1\text{-}C)(L_o^{0.5})/(S_o^{0.333})$

Where: C = runoff coefficient L_o = length of overland flow, (feet, 500-foot max)

S_o = average basin slope (percent)

4. The equation for overland flow time, T_o, is generally adequate for distances up to 500 feet. For longer basin lengths, the runoff will combine and the sheet flow

assumption is no longer valid. The time of concentration would then be overland flow in combination with the travel time, T_f, which is calculated using the hydraulic properties of the swale, ditch, or channel. The time of concentration is the sum of the overland flow time, T_o, and the travel time, T_f.

C. Runoff Coefficient: The runoff coefficient, C, represents the integrated effects of infiltration, evaporation, retention, flow routing, and interception, all of which affect the time distribution and peak rate of runoff. Determination of the runoff coefficient requires judgment and understanding on the part of the design engineer. The recommended range of C values for different surface characteristics as well as for different aggregate land uses are shown below. Coefficient values selected from the range available shall be consistent with the urbanized percent imperviousness (i.e. minimum percent imperviousness requires minimum runoff coefficient value). Also, for flat slopes and permeable soils, use the lower values. For steep slopes and impermeable soils use the higher values.

Runoff Coefficients/Percent Imperviousness for Rational Method

Land Use or Surface Characteristic	Percent Imperviousness	Runoff Coefficients
BUSINESS:		
Commercial Areas	70 to 95	0.70 to 0.95*
Neighborhood Areas	60 to 80	*
RESIDENTIAL:		
Single Family	35 to 50	0.47 to 0.64*
Multi-unit (detached)	45 to 55	*
Multi-unit (attached)	65 to 75	*
½ acre lot or larger	30 to 45	*
Apartments	65 to 75	*
INDUSTRIAL		
Light uses	70 to 80	*
Heavy uses	80 to 90	
PARKS, CEMETERIES	4 to 8	*
PLAYGROUNDS	40 to 60	*
RAILROAD YARDS	35 to 45	*
STREETS		
Paved	90 to 100	0.95
Gravel	50 to 70	0.65
DRIVES AND WALKS	90 to 100	0.95
ROOFS	85 to 95	0.95
LAWNS		
Sandy Soils	5 to 10	0.10 to 0.20
Clayey soils	10 to 30	0.13 to 0.35

* Runoff coefficient to be calculated using actual impervious area and soil groups. Use values in the following table.

Runoff Coefficients – SCS Hydrologic Soil Groups

Land Use or Surface Characteristic		A	B	C	D
LAWNS AND PASTURES					
Flat	0-2% slope	0.08	0.15	0.22	0.30
Average	2-6% slope	0.13	0.20	0.27	0.35
Steep	greater than 6% slope	0.18	0.25	0.32	0.40
WOODLAND					
Flat	0-2% slope	0.06	0.13	0.20	0.26
Average	2-6% slope	0.11	0.18	0.25	0.31
Steep	greater than 6% slope	0.17	0.23	0.29	0.36
MEADOW					
Flat	0-2% slope	0.05	0.12	0.19	0.25
Average	2-6% slope	0.10	0.17	0.24	0.30
Steep	greater than 6% slope	0.15	0.22	0.29	0.35
CULTIVATED					
Flat		0.20	0.27	0.34	0.40

D. Intensity: The intensity, I, is the average rainfall rate in inches per hour for the period of maximum rainfall of a given frequency having a duration equal to the time of concentration. For a given time of concentration, T_c, and a given design storm frequency, the rainfall intensity, I, can be obtained using the following equation:

$$I = d/(T_c + e)^f$$

Where

I = Rainfall Intensity, inches per hour
T_c = Time of Concentration, minutes
d, e, f = Parameters defined in below

Rainfall Intensity Parameters

Design Storm	Parameter d	e	f
2 Year	56.43	11.5	0.81
5 Year	72	15	0.80
10 Year	82	15	0.80
25 Year	95	15	0.80
50 Year	108	15	0.80
100 Year	120	15	0.80

Source: Drainage Design Manual, ODOT, February, 1988

0505.3 SCS Unit Hydrograph Method

A. Introduction: A hydrograph method shall be used to determine peak runoff rates from watersheds larger than 60 acres, (which is the upper limit of the Rational Method), and for all detention pond analyses. Paragraph 0505.1 indicates methods applicable to various size watersheds. This section contains brief explanations of the various

hydrograph methods; however, the design engineer is assumed to be familiar with the basic assumptions and limitations regarding the applicability of the method used.

B. Design storm precipitation:

1. The design storm for the Owasso area shall have a minimum duration of twice the time of concentration for peak flow calculations. For design of detention storage basins, a 24-hour storm shall be used.

2. A precipitation hyetograph shall be used as the input for all runoff calculations. The specified precipitation is assumed to be uniformly distributed over the watershed. The hyetograph represents average precipitation depths over a computation interval.

3. The unit duration incremented shall be in multiples of one, two or five minutes (e.g., 1, 2, 5, 10, or 15-minutes) with the maximum unit duration to be 15 minutes under most circumstances. An acceptable unit storm duration should not exceed one-fifth of the time to peak of the watershed, t_p. As an example, if the watershed has a t_p of 35 minutes, then an appropriate unit storm duration would be five minutes.

C. SCS unit hydrograph method: The Soil Conservation Service (SCS) method is presented in detail in Section 4 of the U.S. Department of Agriculture *Soil Conservation Service Engineering Handbook and Model Drainage Manual*, American Association of State Highway and Transportation Officials, 1991. The SCS computer program TR20 or the U.S. Army Corps of Engineers computer program HEC-1 or HEC-RAS are acceptable ways of utilizing the SCS methodology. The SCS publication TR55 may be used for areas up to 2,000 acres.

0506 STREET DRAINAGE

0506.1 Criteria for Street Drainage

A. Depth in streets: Use of streets for conveyance of stormwater runoff shall be within the following limitations:

1. For the 10-year frequency rainstorm, two driving lanes of arterial streets and one driving lane for collector streets shall remain open. Depth of flow shall not exceed curb height for residential streets. Where no curb exists, stormwater encroachment shall not extend past the street right-of-way.

2. At sump locations, the water depth shall not exceed 12 inches above the top of the grate for the 100-year frequency rainstorm. But in no case, shall the 100-year flow extend beyond the right-of-way.

3. Where sump collection systems are used, a permanent overflow route shall be contained in a dedicated drainage easement providing an emergency bypass in the event of complete blockage of the sump inlets. Where feasible, concrete flumes are the preferred emergency overflow structure.

4. Where driveways are downgrade from the street section, the drive to street transition shall be designed to prevent water from flowing down the driveway.

B. Location of storm sewers: Storm sewer shall not be placed within the wheel path of any driving lane of the pavement. The traffic lane is defined as the normal width provided for each lane and delineated by pavement stripes. The preferred location of the storm sewer is according to the following order of priority listed.

1. Behind the curb

2. Down the center of the traffic lane

3. On centerline

0506.2 Drainage Impact on Streets

A. Sheet flow: To minimize the effects of hydroplaning and splashing of sheet flow, the streets of Owasso shall be designed with a 2% (1/4" per foot) cross slope. In addition, for arterial streets, the amount of flow permitted in the street is limited to the outside lane before a storm sewer inlet is required (Refer to Paragraph 506.1.A).

B. Cross flow: Cross flow over tops of streets is not preferred but, if necessary, shall be accounted for in the drainage calculations and shall be limited to intersections. The depth of flow for the 10-year event shall not exceed 3 inches.

C. Concrete valley gutters: Concrete valley gutters shall be used as necessary to transport flow across the crown of a street, particularly at intersections. Valley gutters should be minimized at locations other than intersections. When a valley gutter is designed for locations other than intersections, a drop inlet shall transport the flow to the stormwater conveyance system. The width of the valley gutter will be determined by the depth required with a side slope of no more than 5% but shall be no less than three feet. Valley gutters shall be constructed with Portland cement concrete and in accordance with Standard Detail STRT-07A.

0506.3 Hydraulic Evaluation

A. Curb and gutter capacity:

1. The allowable storm capacity of each street section with curb and gutter shall be calculated using the modified Manning's formula:

$$Q = 0.56(Z/N)S^{1/2}Y_T^{8/3}$$

Where: Q = discharge is cfs
Z = reciprocal of the street cross slopes (S_x,ft/ft)
Y_T= depth of flow at the gutter (feet)
S = longitudinal grade of street (ft/ft)
N = Manning's roughness coefficient

2. Manning's roughness coefficient, N, shall be used according to the applicable construction condition as shown below.

Manning's N-values for Street Gutters

Construction Type	N
Concrete gutter troweled finish	0.012
Asphalt Pavement	
Smooth texture	0.013
Rough texture	0.015
Concrete gutter with asphalt pavement	
Smooth	0.013
Rough	0.015
Concrete pavement	
Float finish	0.014
Broom finish	0.016
Brick	0.016

Note: For gutters on flat grade where sediment may accumulate, increase all above values of N by 0.002.
Source: Drainage Design Manual, ODOT, February, 1988

3. When the street cross section has different cross slopes, capacity computation shall take into account the various cross slopes.

4. Calculations for inlets, pipes, and gutter flow shall be summarized and tabulated on the plans.

B. Roadside ditch capacity: The capacity of a roadside ditch shall be computed using Manning's equation. The allowable flow over the paved portion of the street is computed according to Paragraph 0506.3.A. This capacity of the roadside ditch and street capacity are combined to determine the entire street section capacity. The paved street portion contributes to the total capacity only when the depth of flow in the roadside ditch is exceeded for the design storm. As in streets with curb and gutter, the maximum allowable depth at the pavement edge shall not exceed the limits set in Paragraph 0506.1.A. Borrow ditches shall not exceed three (3) feet deep with maximum side slopes of 3:1 H:V (4:1 H:V preferable).

0507 STORM SEWER INLETS

0507.1 Design Criteria

A. Inlet types:

1. Four types of inlets are used in the City of Owasso: curb opening inlets, combination grated with curb opening inlets, median inlets, and area inlets. Multiple inlets occur when more than one inlet (of the same type) are used in a continuous series, resulting in greater flow interception capacity.

2. Inlet types shall be in accordance with the City's Standard Details.

3. On arterial streets offset type inlets, ODOT Standard SSCD-1-15, shall be used.

B. Location of inlets:

1. Inlets shall be located at all low points in the gutter grade, on side streets at intersections where runoff would flow onto an arterial street or highway and upgrade of bridges to prevent runoff from flowing onto the bridge deck. Inlets are also required when the allowable depth of flow in the gutter is exceeded. Inlets shall not exceed 600-foot spacing unless special conditions prevent such spacing and shall be approved by the Engineer.

2. Inlets at intersections shall be located in such a manner that no part of the inlet will encroach upon the curb return. No drainage structure shall be permitted at a wheelchair ramp. Inlets on a continuous grade in the interior of a block should be placed upstream of a nearby driveway, if possible. The flowline and top of curb elevations shall be shown on all inlets.

3. Runoff from areas greater than one half (½) acre outside the roadway shall be collected before it reaches an arterial or collector street. Parking lots shall have internal drainage systems so as to reduce concentrated flows into streets. This item does not apply to single-family residential lots on local streets.

C. Time of concentration: A maximum T_c of 5 minutes to the first inlet shall be used for commercial and industrial areas.

D. Spacing between inlets: Spacing between inlets shall be such that depths of flow and widths of spread requirements are not violated. Maximum spacing shall be 600 feet.

E. Interception and bypass:

1. No more than 25% of the street runoff shall be allowed to bypass an inlet and the remaining flow shall be intercepted at the next inlet. As many of the inlets as possible shall be sump inlets.

2. The design engineer will determine the type of inlet to be used and the percent of flow to be intercepted at a particular location.

3. Hydraulic design of inlets shall be in accordance with Paragraph 0507.2.

F. Inlets in sump conditions:

1. When inlets are placed in a sump, emergency overflow shall be provided as described in Paragraph 0506.1. The drainage easement for this overflow must be shown on the plat for the development.

G. Clogging Factors

1. Hydraulic design charts presented in the document were developed with the assumption that all openings are clear, i.e., no portion of the curb or grate opening is clogged with any sort of debris. Clogging is a function of the frequency of the street sweeping and maintenance activities.

2. The following clogging factors are required to deduce the theoretical interception given by the hydraulic design charts. A clogging factor of 0/8 is interpreted to mean that the intercepted discharge obtained from the charts is multiplied by 0.8 to obtain the allowable capacity, i.e., the allowable capacity of the inlet is 80% of the theoretical capacity. The method by which these clogging factors are incorporated with the hydraulic design charts is detailed in Paragraph 0507.2.

INLET TYPE	INLET LOCATION	CLOGGING FACTOR
Curb opening only	**Continuous grade**	**0.8**
Curb opening only	**Sump**	**0.8**
Combination curb and grate	**Continuous grade**	**1.0**
Combination curb and grate	**Sump**	**0.7**
Median	**Sump(1)**	**0.8**
Grate only(2)	**Continuous grade**	**0.6**
Grate only(2)	**Sump**	**0.5**

Notes: (1) Because of the grading required around a median inlet, the inlet only operates in a sump condition during design flows.

(2) Inlets with grates only are not permitted but are included in the table for evaluation of existing conditions.

3. The curb inlets shall be located such that, on four-lane streets, at least one driving lane (each way) has no water and, on two-lane streets, the width of one traffic lane is open.

0507.2 Hydraulic Evaluation

A. Methodology: Curb/grate inlet capacities shall follow industry specified methods.

B. Grated inlets:

1. Grated inlets (at curb) without curb opening are not permitted.

2. Bicycle safe grates (in combination with curb openings) are the only grates approved by the City of Owasso within the street right-of-way.

3. When a grate is used in conjunction with a curb opening directly behind the grate, only the hydraulic capacity of the grate shall be utilized to estimate the flow that is intercepted, since the curb inlet portion is reserved to serve as overflow when the grate is blocked by debris.

4. Grate interception capacities shall be determined for the specific grate to be used in the project. For example, if the grate inlet is manufactured by Neenah Foundry, use Neenah's method of computing the capacity.

C. Curb opening inlets: Curb opening inlets shall be manufactured cast iron inlets.

D. Tabulations: Drainage areas, 10-year and 100-year flows shall be summarized and tabulated on the plans. The table shall also be a part of the Engineering Report.

0508 STORM SEWER PIPE SYSTEM

0508.1 Introduction

A "storm sewer system" refers to a system of inlets, pipes, manholes, junctions, outlets; and other appurtenant structures designed to collect and convey storm runoff to a defined drainageway. A "drainage system" also includes curbs and gutters, roadside ditches, swales, channels, and detention systems for the control of overland runoff. A storm sewer system is required when other parts of the drainage system no longer have the capacity for additional runoff without exceeding the design criteria.

0508.2 Design Criteria

A. Design storm frequency:

1. The storm sewer system, beginning at the upstream end with inlets, is required when the allowable street capacity or overflow capacity is exceeded for the design storm. The storm sewer system should be designed for the larger of the following two events to prevent violation of the criteria in Subsection 0506:

   a. The flow equal to the difference between the 10-year storm and the allowable street capacity (as stated in Paragraph 0506.1.A.1) OR

   b. The flow equal to the difference between 100-year storm and the capacity within the street right-of-way.

2. The intent is to intercept the 10-year flood and convey the flow in a storm sewer. However, it is impractical to intercept all the runoff in the street at the inlet and some "carry-over" flow will occur. The procedure simply puts a limit on the amount of carry-over flow that can occur in the street.

B. Construction materials: Storm sewers within the City of Owasso shall be constructed using reinforced concrete, high-density polyethylene (HDPE) or coated metal alloy. The materials, pipes, and appurtenances shall meet the requirements of the City's Standard Details

C. Vertical alignment:

1. Minimum cover: For pipe under paved areas, the sewer grade shall be such that a minimum cover is maintained to withstand AASHTO HS-20 loading on the pipe. The minimum cover depends upon the pipe size, type and class, and soil bedding conditions, but shall not be less than one foot from the top of pipe to the finished grade at any point along the pipe. If the pipe encroaches into the street sub-grade, a variance must be granted by the Engineer.

2. Manholes: Manholes will be required whenever there is a change in size, alignment, elevation grade and slope, or where there is a junction of two or more

sewers. For sewers equal to or larger than 60 inches in diameter, pre-formed smooth transitions shall be approved by the Engineer. The maximum spacing between manholes for various pipe sizes shall be as shown below.

Storm Sewer Alignment and Size Criteria

Manhole Spacing

Pipe Size	Maximum Spacing-Manholes	Minimum Manhole Size
15 to 24 Inches	300 Feet	4 Feet
27 to 42 Inches	400 Feet	5 Feet
48 Inches	500 Feet	6 Feet
54 to 66 Inches	500 Feet	8 Feet
>66 Inches	500 Feet	Junction Structure

Minimum Radius For Radius Pipe:

Short radius bends shall not be used on 36-inch diameter or less for public systems.

Minimum Pipe Diameter:

Type	Minimum Equiv. Pipe Dia.	Minimum Cross-Section
Main trunk	15 Inches	1.23 Sf
Lateral from Inlet	15 Inches	1.23 SF

Source: *Stormwater Criteria Manual*, City of Tulsa

3. Water main separation: The minimum vertical clearance between storm sewer and water main (for new construction), either above or below shall be 24 inches. Ductile iron pipe (with proper bedding) or concrete encasement of the water line will be required for clearances of 24 inches or less when the clearance between existing water mains cannot be maintained.

4. Sanitary sewer separation: The minimum vertical clearance between storm sewer and sanitary sewer (for new construction), either above or below, shall be 24 inches. In addition, when an existing sanitary sewer main lies above a storm sewer, or within 24 inches below, the sanitary sewer shall have impervious encasement or be constructed of ductile iron or PVC water pipe for a minimum of 10 feet on each side of the storm sewer crossing.

5. Siphons: Siphons or inverted siphons are not allowed in the storm sewer system.

6. The hydraulic grade line (HGL) and energy grade line (EGL) shall be shown on stromwater profile sheets (see Paragraph 0508.2 F.2). The HGL shall be at or above the level of normal pool elevations for permanent pool (wet) detention ponds. No outlets shall be designed to discharge below the normal pool.

D. Horizontal alignment:

1. Storm sewer alignment between manholes shall be straight except when accepted in writing by the Engineer. Approved curvilinear storm sewers may be constructed using pipe bends or radius pipes.

2. A minimum horizontal clearance of ten feet is required between sanitary and water utilities and the storm sewer. When it is not possible to obtain the required clearance, pipe shall be constructed per Subchapter 9 of the ODEQ Administrative Code, Chapter 655.

3. The storm sewer shall be behind the curb within the street right-of-way.

4. Manholes and catch basins shall be stationed on the plan sheets using centerline stationing with left or right offset dimensions. Inlets with grates shall be stationed at the centerline of the grated section.

E. Pipe size: The minimum allowable pipe size for storm sewers shall be 15 inches. Storm sewer shall be closed conduit up to 60-inch diameter pipe or its hydraulic equivalent. Stormwater drainageway systems that must carry a flow greater than the capabilities of a 60-inch conduit system may be a closed system, an improved channel constructed in accordance with the Standard Details and floodplain policies, or an unimproved channel in accordance with floodplain zoning ordinances.

F. Storm sewer capacity and velocity:

1. The capacity and velocity shall be based on the Manning's n-values presented in Subsection 0506. The maximum full flow velocity shall be less than 20 feet/sec. Higher velocities may be accepted by the Engineer if the design includes adequate provisions for uplift forces, dynamic impact forces and abrasion. The minimum velocity in a pipe based on full flow shall be 2.5 feet/sec to avoid excessive accumulations of sediment.

2. The hydraulic grade line (HGL) shall be shown on all profiles of storm sewers including more than one pipe section. The energy grade line (EGL) for the design flow shall be no more than one foot above the final grade at manholes, inlets, or other junctions. To insure that this objective is achieved, the HGL and the EGL shall be calculated by accounting for pipe friction losses and pipe form losses. Total hydraulic losses will include friction, expansion, contraction, bend, manhole, and junction losses.

3. Box culverts and bridges shall have adequate capacity to pass 100-year fully urbanized flows with a minimum of 12 inches freeboard to the crown of the roadway. Backwater analysis shall be provided by the consulting engineer to illustrate compliance with this requirement.

G. Miscellaneous criteria:

1. No pipe shall be installed downstream having a smaller capacity than the upstream pipe or combination of upstream pipes.

2. Concrete pipe shall not be less than C-76, Class III.

3. HDPE pipe shall be AASHTO M-294 corrugated outside with a smooth core.

4. Circular Pipe – All joints shall be a confined O-ring gasket meeting ASTM C443. All pipe 36 inches in diameter and smaller shall have bell and spigot joints. Pipe larger than 36 inches in diameter may have tongue and groove joints. If the hydraulic grade line is less than 6 inches above the top of the pipe during the 100-year event, the O-ring gaskets may be omitted, provided each joint is wrapped with 24 inches of approved filter fabric.

5. Junctions between different pipe sizes shall be made with the top inside of the downstream pipe no higher than the top inside of the upstream pipe.

6. Manholes or junction boxes shall be required at all changes in grade, alignment and junctions between two or more different pipe sizes.

7. The horizontal clear distance between pipes being placed in the same trench shall be a minimum of 24 inches or one-third the diameter of the largest pipe, whichever is greater. This application includes multiple pipes for culverts.

8. The largest diameter storm sewer entering or exiting a 4-foot diameter manhole shall be 24 inches. Junction boxes shall be installed when 4-foot diameter manholes cannot be used.

9. Drainage pipes shall not enter manholes within the Corbel (neck down) section.

10. All headwalls and slopewalls shall be concrete.

11. Pipes discharging at a steep gradient into drainageways and detention facilities shall be provided with a slope wall.

12. Preformed end sections are not allowed. Concrete wingwalls with aprons or concrete slope walls shall be installed.

13. Discharge points with 18-inch pipe or larger shall be fitted with a protective grate to prevent access into the pipe.

H. Storm sewer inlets and outlets:

All storm sewer outlets into open channels shall be constructed with a concrete slopewall or headwall with wingwalls. Erosion control measures shall be taken on all headwall and slopewall applications. When the outlet velocity exceeds six feet per second (6 fps), energy dissipaters shall be provided for energy dissipation.

0509 OPEN CHANNELS

0509.1 Channel Design

A. Design: Channels shall be designed in accordance with sound engineering principles.

B. Channel geometry:

1. Trapezoidal channels: Trapezoidal channels shall have a minimum bottom width of 4 feet with side slopes of not steeper than 3.5 to 1 for sodded sections and a minimum bottom width of 4 feet with side slopes of not steeper than 1:1 for paved or rock lined sections. Where the public may be exposed to hazards and nuisances of open channels, appropriate measures shall be taken to exclude the public from the perilous area.

2. Rectangular channels: Rectangular channels shall be approved by the Engineer before design is begun. All rectangular channels are to be concrete on all sides.

C. Manning's N-value: Manning's equation in the calculations of hydraulic characteristics of channels will be acceptable. The "N" value used for channels shall be based on the individual channel characteristics, as shown below. Designers should anticipate growth of future vegetation as a natural maturation process of the channel. Values less than 0.05 shall be justified by the design engineer.

Manning's N-Value for Open Channels

Channel Type	N-Value Range	Recommended Value
Grass-lined, maintained	.029 to .100	
Grass-lined, not maintained	.045 to .10	.035
Natural Streams	.025 to .100	Note (1)
Riprap Lined		
1. Ordinary riprap	.025 to .050	.035
2. Gabions	.025 to .050	.035
3. Grouted riprap	.023 to .030	.027
4. Slope mattress	.025 to .033	.028
Concrete Lined		
1. Float finish	.013 to .016	Note (2)
2. Slip formed	.013 to .016	Note (2)
3. Gunite	.016 to .023	Note (2)

Notes:
1. Source: Chow, V.T., Open Channel Hydraulics, McGraw-Hill Book Company, 1959, and pictures
2. High value used for capacity determination and low value used for velocity consideration

D. Minimum slope: Channels shall have minimum slopes of 0.1% for concrete-lined channels and 0.2% for grass lined channels. Variations must be approved.

E. Minimum velocity: Minimum velocity in a drainageway system, having a roughness coefficient less than or equal to 0.015, shall be 2.5 feet/sec to avoid sedimentation.

F. Maximum velocities: Velocities shall not exceed 6 feet/sec for sections sodded in grass. Velocities in concrete lined or paved sections shall not exceed 15 feet/sec. The dissipation of energy shall be required at the confluence of improved channels with natural channels through the use of dissipaters, stilling basins and etc. which shall be designed in accordance with FHWA HEC #14 *Hydraulic Design of Energy Dissipaters for Culverts and Channels Drainage Manual*.

G. Freeboard: The design water surface elevation should be kept within the channel banks. Any deviation from this requirement requires approval of the Engineer. A 1-foot freeboard above the energy grade line should be added to calculated flow depths to determine minimum channel depths.

H. Alignment: The centerline radius of a curve on an improved channel shall be a minimum of three (3) times the maximum top width at the design flow depth.

0509.2 Channel Types

A. Trickle channels: All channels altered or improved from the natural state will require a paved trickle channel unless a variance is granted by the Engineer. Sodding, or other methods of erosion control shall be required adjacent to the paved channel.

B. Concrete flumes: Concrete flumes in lieu of enclosed pipe shall be allowed as overflow protection for storm sewer systems, and to drain areas not exceeding five (5) acres in size. All concrete flumes shall extend to the rear of adjacent lots and shall discharge into a dedicated drainage facility or channel. There will be no special freeboard requirement for concrete flumes.

C. Rectangular concrete channels: Concrete channels shall be designed to withstand the earth loads while the channel is not in use. The thickness of the vertical concrete walls shall be a minimum of 12 inches. Weep holes and under drains shall be installed to prevent floatation.

D. Fill areas: When storm sewers are placed in fill areas, all materials in the fill area shall be constructed to a 95% standard proctor density prior to the laying of the pipe.

E. Roadside ditches: Roadside ditches shall conform to requirements of this section.

0509.3 Floodplain Data

Base Flood Elevation (BFE) or floodplain boundary changes shall be approved by FEMA via the development and approval of a Conditional Letter of Map Revision (CLOMR) and Letter of Map Revision (LOMR).

0510 HYDRAULIC STRUCTURES

0510.1 Definitions

A. Culverts: A culvert is defined as a closed conduit for the passage of water under an embankment, such as a road, railroad, or driveway. The distinction between a culvert and a sewer is the means by which flow enters the conduit. Flow normally enters a culvert by an open channel, generally at a similar elevation and a culvert usually crosses a street.

B. Bridge: A bridge is constructed with abutments and superstructures, which are typically concrete, steel, or other materials. Since the superstructures are generally not an integral structural part of the abutments, and are therefore free to move, the hydraulic criteria for bridges is different than for culverts. Bridges are also usually

constructed with earth or rock inverts, whereas culverts are typically the same material throughout the waterway opening.

0510.2 Culverts

A. Construction materials: Culverts shall be constructed of reinforced concrete. Other materials may be used on a case-by-case basis on acceptance by the Engineer.

Culvert Materials

Pipe Material	**Standard**
Reinforced Concrete Pipe	
Round	ASTM C-76 or AASHTO M-170
Elliptical	ASTM C-507 or AASHTO M-207
Arch	ASTM C-506 or AASHTO M-206
HDPE Pipe	AASHTO M-294
Pre-cast Concrete Manholes	ASTM C-478 or AASHTO M-199
Pre-cast Concrete Box	ASTM C-789/C-500,AASHTO M-259/273 or ODOT
Concrete Cast-in-Place Box	ODOT Standard

B. Sizing method: Culvert design shall follow the methodology presented in *Hydraulic Design of Highway Culverts*, Hydraulic Design Series HDS No. 5, FHWA, U.S. Department of Transportation and *Drainage Manual*, Oklahoma Department of Transportation, 1992.

C. Design frequency: Minimum design frequency for culverts shall be 100-year.

D. Minimum size:

1. Pipe Culverts: 18-inch diameter equivalent.

2. Box Culverts: 3 feet wide, 3 feet in height.

E. Velocity limitations:

1. In design of culverts both the minimum and maximum velocities must be considered. A minimum velocity of 2.5 feet/sec at the outlet is required to assure a self-cleaning condition of the culvert.

2. The outlet area shall include a headwall with wingwalls or an end-section in addition to the riprap protection if required. Where outlet velocities exceed six feet per second, erosion control measures shall be taken. Energy dissipaters shall be provided as required.

F. Structural design: Culverts shall be designed to withstand an HS-20 loading in accordance with the design procedures of AASHTO *Standard Specifications for Highway Bridges* and with the pipe manufacturers' recommendations. The minimum cover over top of the pipe shall be 12 inches unless otherwise accepted by the Engineer.

G. Driveway crossings: Driveway culverts shall be sized to pass the 10-year ditch flow capacity without overtopping the driveway. The minimum size culvert shall be a 15-

inch round pipe, or equivalent, for all streets. Sloped headwalls required per the City's Standard Details.

0510.3 Bridges

A. Bridge sizing criteria: The sizing criteria set forth in Paragraph 0510.2 for culverts shall apply as follows:

1. Freeboard: Freeboard is defined as the vertical clearance of the lowest structural member of the bridge superstructure above the water surface elevation of the design frequency flood. The minimum freeboard shall be 1 foot for the 100-year frequency flood, unless accepted by the Engineer.

2. Backwater: Backwater is defined as the rise in the flood water surface due to the restrictions created by the construction of the bridge. The maximum backwater shall be 1 foot.

B. Velocity limitations: The velocity limitations through the bridge opening are controlled by the potential abutment scour and subsequent erosion protection provided. When using riprap for the channel lining and/or protection of the abutments and wingwalls, the maximum channel velocity is limited to 15 feet/ sec.

C. Hydraulic analysis: The hydraulic design of bridge crossings shall be in accordance with *Drainage Manual*, Oklahoma Department of Transportation, most current version.

D. Inlet and outlet configuration: The design of bridges shall include adequate wingwalls of sufficient length to prevent abutment erosion and to provide slope stabilization from the embankment to the channel. Concrete aprons on the inlet and outlet transition slopes shall be provided to protect from the erosive forces of eddy current.

E. ODOT standards: Bridges shall be designed in accordance with AASHTO/ODOT criteria. Rails shall comply with ODOT Standard Details.

0511 STORAGE AND INFILTRATION

0511.1 General

A. Generally, urbanization results in more impervious area and a reduction in floodplain storage, both of which contribute to increased flow rates. The development plan and/or Engineering Report shall incorporate permanent, post-construction means (such as basins, ponds, infiltration trenches, dry wells and porous pavement) to provide for storm water infiltration, and reduce erosion and sediment transport.

B. If improvements are made to any natural channel downstream from an area which requires a minimum pipe diameter of 48 inches to discharge a 10-year frequency storm, current floodplain storage must be maintained.

C. The detention storage shall accommodate the excess runoff from a 100-year frequency storm. The excess runoff is that runoff generated due to urbanization

which is greater than the runoff historically generated under existing conditions, for a given frequency storm. Detention facilities shall be designed so that the peak rate of discharge does not exceed that of the pre-development conditions for all storm events up to and including the 100-year event. Furthermore, facilities shall be designed to minimize increase in runoff volume and avoid detrimental effect to adjacent and downstream properties. Detention shall be provided for all storms.

D. Outlets for the stormwater collection system discharging into a detention area with a permanent pool shall be designed such that no outlet discharges below the normal pool.

E. Final as-built topography shall be provided to the Engineer to assure the detention area was constructed as designed.

F. Maintenance of the basin shall be the Developer's responsibility during and following infrastructure installation until such time as the homeowner's association assumes the responsibility.

G. Parking surfaces shall not be used for storm water detention unless allowed by special approval in infill areas only.

0511.2 Design Criteria

A. Flow determination methods: For determining the design flow to storage facilities, the methods contained in Paragraph 0505.1 are approved. For detention design, SCS or Snyders hydrograph methods shall be used.

B. Existing ponds and channel storage shall be used in flood routing under pre-existing conditions.

C. Design storm: The design storms for detention shall have a duration of 24 hours. Rainfall depths shall be in accordance with Subsection 0504.

D. Engineering report: All calculations for detention facilities shall be submitted for review by the Engineer. The submittal shall include hydrographs for both existing and developed conditions, detention facility stage-area-discharge relationships, outlet structure details, and a stage versus time analysis through the facility.

E. Time increment: The time increment used in developing the rainfall distribution and in reading off the ordinates of the unit hydrograph may be rounded off to the nearest whole time interval or to the nearest time increment.

F. Rainfall patterns: Rainfall patterns shall be consistent with the modeling technique used. An SCS Type II synthetic storm distribution is preferred.

G. Planning: Floodplain areas and detention facility locations shall be identified at the preliminary plat stage to illustrate how these areas will be managed during and after construction.

H. Backwater analysis: If a tract of land under development has a floodplain area within its boundary, the information that must be furnished either with the preliminary plat or before the final plat is submitted, shall include:

1. A backwater analysis on the existing drainage system.

2. A backwater analysis on the proposed drainage system.

I. Location:

1. Detention facilities shall be located in areas acceptable to the City. Each facility shall incorporate methods to minimize erosion and other maintenance reducing designs.

2. Detention facilities are not to be located in non-accessible areas which may demand continued high maintenance costs.

J. Additional storage:

1. If the detention facility is approved by the City to serve areas outside the subdivision in which it is located, such additional areas shall be specifically identified in the provision for detention.

2. Additional detention storage, in excess of the required storage for a drainage area, can be provided to satisfy the detention requirements for a tract of land downstream of the detention facility, providing the detention facility is constructed prior to the development of the downstream tract.

K. Detention consolidation: A minimal number of detention facilities is encouraged for each development. Regional detention facilities are encouraged for phased or cooperative development in a drainage basin. For phased developments, detention facilities shall be constructed in the first phase.

L. Multiple drainage areas: If runoff has a natural tendency to drain in several directions for a given development tract of land where detention is required, then detention storage shall be provided for the largest drainage area. Additionally, detention storage may be provided at the same facility in order to satisfy detention requirements for a separate drainage area on the same development, provided that;

1. The whole development tract of land is in the same local watershed.

2. The smaller drainage area(s) that, has/have been compensated for does/do not, either singly or in combination, adversely impact the health, welfare and safety of the general public downstream.

M. Diverting drainage courses: If a tract of land being developed is located in more than one watershed, grading work to divert flows from one watershed to another will not be permitted without proper detention facilities for all watersheds.

N. Platting: The detention area shall be identified as a separate platted area. As appropriate, it may consist of one or more platted lots, a separate block, or it may be identified as a reserve area.

O. Restrictive covenants: Provision for the detention facility shall appear among the plat's restrictive covenants.

P. Future improvements: In the event the detention facility as (a result of drainage improvements) becomes unnecessary by action of the City Council, the facility may be vacated as provided for in the covenants or applicable law.

Q. Ingress/Egress: An access way at least 20 feet wide shall be provided to any required detention area. Access may be provided by frontage on a dedicated public street or by an access easement from a dedicated public street to the detention area.

R. Embankment: Any dam or berm shall be designed in accordance with the dam safety criteria of the Oklahoma Water Resources Board. The core of the dam shall be impermeable clay.

S. Maintenance: The maintenance responsibility for on site detention facilities shall remain with the private sector and appropriate covenants shall be obtained to secure such maintenance.

T. Permanent pool (wet) detention ponds: Wet ponds shall be reviewed on a case-by-case basis. Ponds shall be designed to discharge as described above. The post-development discharge rate shall not exceed the pre-development discharge conditions for all storm events up to and including the 100-year event.

0511.3 Physical Features

A. General: Detention dams or dikes shall be constructed as earth filled and non-overflow type dams.

B. Top of berm: Spillways shall be constructed to pass the 500-year flood event with a minimum of 12 inches of freeboard on the earth dam structure unless the structure falls into a category requiring more stringent criteria. Cross sections shall be provided indicating the 5-, 100- and 500-year pool elevations.

C. Side slopes: Side slopes on detention facilities shall not be steeper than 4 horizontal to 1 vertical.

D. Access road: Access road, with grade of 10% or less, shall be provided to the detention areas for maintenance purposes.

E. Low flow trickle channel: Detention facilities shall be provided with a low flow concrete trickle channels from the inlet(s) to the outlet structure to transmit low flows.

F. Outlet structures: Storm sewer outlets into detention pondd shall consist of pipes and/or concrete structures and shall be protected by a reinforced concrete headwall or slope walls (for 24-inch or less diameter pipe) with energy dissipaters as a minimum

control measure. The hydraulic grade line (HGL) at discharge shall be above the normal pool elevation.

G. Erosion control: All earth slopes and earth areas subject to erosion, such as, adjacent to low flow channels, inlet structures, and outlet structures shall be slab sodded with bermuda sod or protected with other approved erosion control measures. All other earth surfaces, within the area designated for detention facility site, shall have an established growth of bermuda grass. All covered areas shall be fertilized, watered and in an established growing condition prior to completion and acceptance of the detention facility. Requirements of Section 0600, Stormwater Pollution Prevention shall apply.

0511.4 Fee-in-Lieu of Regional On-Site Detention

A. Requirement: Detention facilities shall be designed using the City's hydrologic model and the hydraulic model for the watershed (if available). A Developer shall satisfy his requirement to provide for detention by contributing to the construction of a planned regional detention facility unless it is determined by the Engineer that on-site detention is required because of downstream capacity problems. If a hydrological model is not available for the watershed basin, the Developer must furnish a complete hydrological model at the Developer's expense before fee-in-lieu-of detention can be considered.

B. Contribution amount: The contribution shall be the maximum of either the appropriate percentage of the actual flow contributed or the amount determined as an appropriate portion of the cost of a regional detention facility.

C. Financing: The City shall administer financing with all funds paid before construction.

D. Regional detention: The boundaries of watersheds and priority of acquisition of regional and sub-regional detention sites and construction of detention facilities and location thereof shall be established by the Engineer and approved by City Council. The City will determine if fee-in-lieu of on-site detention is applicable to a specified site.

0512 EROSION AND SEDIMENTATION CONTROL

Criteria for erosion and sediment control is included in Section 0600, Stormwater Pollution Prevention.

0513 APPLICABLE STANDARD DETAILS

STRM-01	Storm Sewer Pipe Installation
STRM-02	Storm Sewer Joint Wrapping Detail
STRM-03	Configuration of Cast Iron Curb Inlets
STRM-04	Storm Sewer Inlet Frame-Type A
STRM-05	Storm Sewer Inlet Frame-Type B
STRM-06	Storm Sewer Inlet Frame-Type C
STRM-07	Curb Inlet-Sheet I
STRM-08	Curb Inlet-Sheet II

STRM-09	Area Inlet
STRM-10	Storm Sewer Box Grate
STRM-11	Storm Sewer Box Culvert
STRM-12	Storm Sewer Headwall-Sheet I
STRM-13	Storm Sewer Headwall-Sheet II
STRM-14	Concrete Slopewall Channel with Underdraw
STRM-15	Concrete "U" Channel
STRM-16	Grass-Lined Channel-Type A
STRM-17	Grass-Lined Channel-Type B
STRT-07A	Valley Gutter

END OF SECTION