# CITY OF DRAPER
# DRAINAGE DESIGN CRITERIA

# October 11, 2012

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Storm drainage and erosion control plan submittal requirements are described in the Appendix to these Drainage Design Criteria. Additional design criteria are found in the Draper City Storm Drainage Master Plan.

Unless provided otherwise, the criteria and methods presented in the following references shall be used in planning and design of each drainage system:

> Urban Drainage Design Manual, Hydraulic Engineering Circular No. 22, September 2009, Federal Highway Administration, FHWA-SA-96-078, http://www.fhwa.dot.gov/bridge/hydpub.htm
> http://www.fhwa.dot.gov/engineering/hydraulics/library_listing.cfm

> Urban Storm Drainage Criteria Manual 2011, Urban Drainage and Flood Control District, http://www.udfcd.org/

Best management practices (BMPs) for controlling stormwater pollution during construction activities shall use the Salt Lake County "Best Management Practices for Construction Activities" document at http://www.pweng.slco.org/stormwater/pdf/cmatrix.pdf.

BMPs for post-construction control of stormwater pollution in new development or redevelopment sites shall utilize Urban Storm Drainage Criteria Manual Volume 3 – Best Management Practices 2011, http://www.udfcd.org/ for selection and design of long-term controls.

Specific criteria for use in the design of stormwater facilities in Draper City are presented in two sections: Hydrologic Criteria and Design Criteria. Hydrologic Criteria includes precipitation, drainage design frequency, design storm distribution and duration, and the storm drainage modeling method. Design Criteria includes street drainage, storm inlets, storm drains, stormwater quantity control facilities, and easements.

# HYDROLOGIC CRITERIA

The Hydrologic Criteria are based on well-established public works methods and engineering principles. These methods have been developed over many years by a variety of private and governmental entities including local, state and federal agencies. The methods, models and data described are widely used and readily available. Much of the information discussed is available from governmental agencies, as well as from the internet websites of the respective agencies.

## PRECIPITATION

Precipitation depths are determined based on the NOAA Atlas 14-Point Precipitation Frequency Estimates data server. Precipitation depths increase with elevation and proximity to the mountains due to the orographic effect. Because of this, the City is divided into three areas for the purpose of developing design rainstorm depths, as shown on Figure 1. The design rainfall amounts to be used are shown in Tables 1 and 2 and are to be applied based on the location of the proposed development.

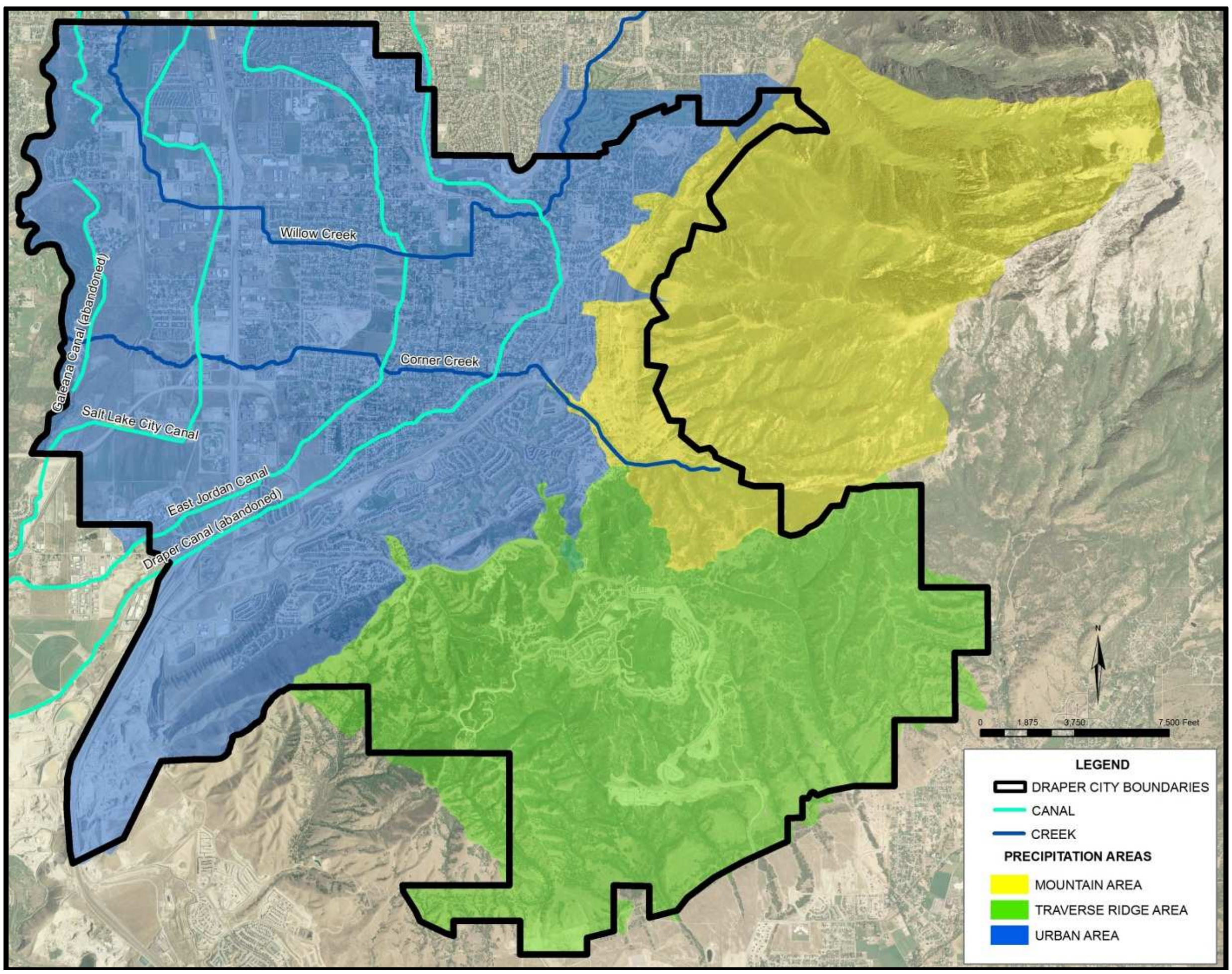



**Figure 1 – Design Rainstorm Depth Precipitation Areas**

**TABLE 1**
**DESIGN RAINFALL DEPTHS FOR URBAN AREA**

| Location | Return Period | 3-Hour Rainfall Depths (inches) |
|---|---|---|
| Urban Area | 10-Year | 0.93 |
| Urban Area | 100-Year | 1.79 |

**TABLE 2**
**DESIGN RAINFALL DEPTHS FOR**
**TRAVERSE RIDGE AREA AND MOUNTAIN AREA**

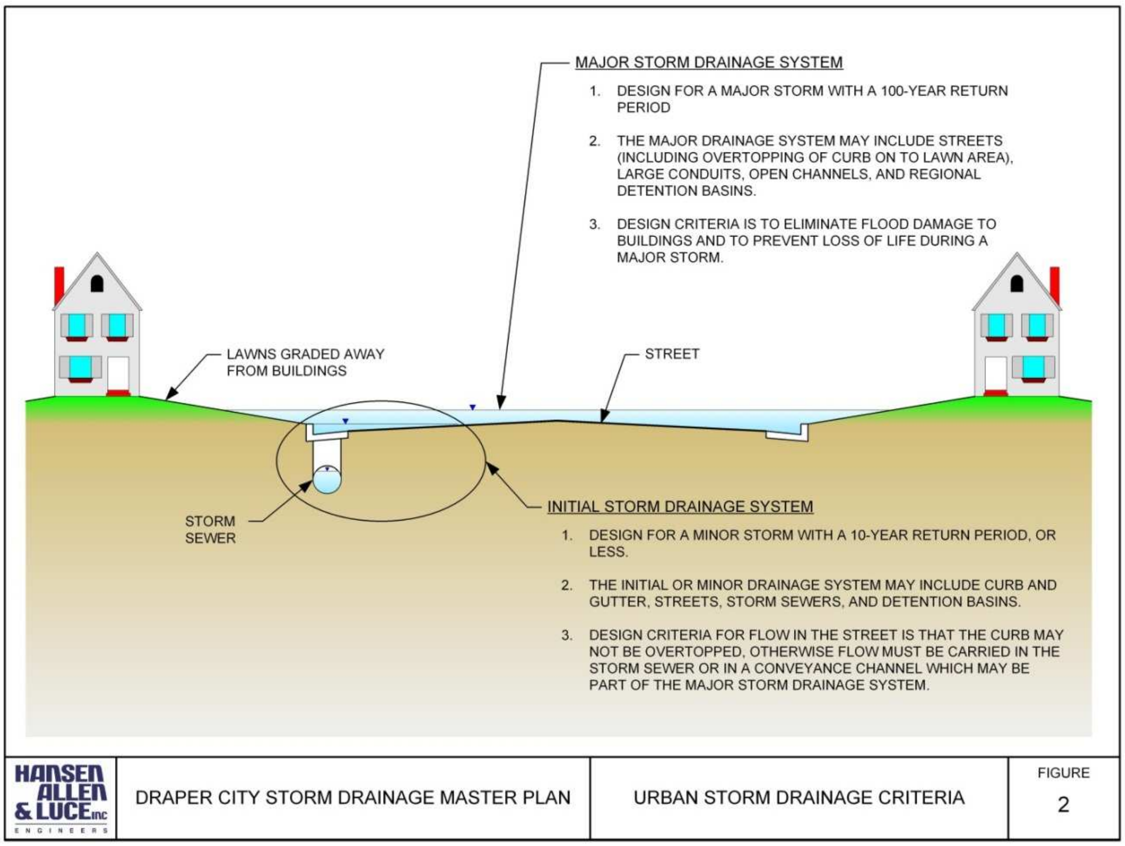
| Location | Return Period | 1-Hour Rainfall Depths (inches) | 3-Hour Rainfall Depths (inches) | 6-Hour Rainfall Depths (inches) | 12-Hour Rainfall Depths (inches) | 24-Hour Rainfall Depths (inches) |
|---|---|---|---|---|---|---|
| Traverse Ridge Area | 10-Year | 0.82 | 1.03 | 1.28 | 1.62 | 1.80 |
| Traverse Ridge Area | 100-Year | 1.64 | 1.87 | 2.06 | 2.52 | 2.62 |
| Mountain Area | 10-Year | 0.91 | 1.17 | 1.50 | 1.96 | 2.30 |
| Mountain Area | 100-Year | 1.80 | 2.10 | 2.39 | 3.03 | 3.35 |

## DRAINAGE DESIGN FREQUENCY

"Every urban area has two separate and distinct drainage systems, whether or not they are actually planned and designed. One is the initial system, and the other is the major system (see Figure 2). To provide for orderly urban growth, reduce costs to future generations, and avoid loss of life and major property damage, both systems must be planned, properly engineered and maintained." (Urban Storm Drainage Criteria Manual, Urban Drainage and Flood Control District, Denver, Colorado, June 2001). The initial and major drainage systems are defined as follows:

- Initial System: The initial storm drainage system includes those components which provide protection against regularly recurring damage from storm runoff. Initial drainage systems include the street curb and gutter, storm drain systems, and local detention basins. These systems shall be designed to safely convey the 10-year storm runoff event.

- Major System: The major storm drainage system includes those components which provide protection against larger, typically rare storms. Included in the major storm drainage system are major channels, swales and culverts, streets, regional detention and retention facilities. This system shall be designed for the 100-year event with the objective to eliminate major damage to structures, homes, and businesses, and to prevent loss of life.




## DESIGN STORM DISTRIBUTION AND DURATION

To compute runoff from a given storm, the distribution of the rainfall through time must be known. Critical runoff events from urban areas along the Wasatch Front are caused by cloudburst type storms which are characterized by short periods of high intensity rainfall. The Farmer-Fletcher (1971) design storm distributions were developed using local Utah recording gauge networks for summer thunderstorm type rainfall events. The Farmer-Fletcher design storm distributions were developed with methodology that preserved the measured individual storm burst rainfall intensities. The storm distribution chosen by Draper City for the Urban Areas (see Figure 1) was developed using a 1-hour Farmer-Fletcher distribution modified by Salt Lake County for a 3-hour storm. Farmer and Fletcher (1971) examined rainfall gauge records and classified storms based on whether the heaviest rainfall of the storm fell in the first, second, third or fourth quarter of the storm period. Farmer and Fletcher found that "first and second quartile storms together comprise 76% of those storms containing a burst of 5-minute duration with a 2-year recurrence interval and 92% of storms containing a burst of 10-minute duration, with a 10-year recurrence interval**.**" Farmer and Fletcher developed model storms for the first and second quartile storms. The 3-hour storm distribution developed for Salt Lake County utilizes a 1-hour Farmer-Fletcher first quartile storm distribution for the central hour of the 3-hour distribution. The remaining two hours of the design storm distribution were distributed symmetrically around the central hour. Use of the 3-hour storm removes the need for a sensitivity analysis for the Urban Area.

Incremental rainfall and total rainfall for use to define the 3-hour design storm distribution are provided in Table 3A for the 10-year storm event and Table 3B for the 100-year storm event.

**TABLE 3A**
**SALT LAKE COUNTY 10-YEAR 3-HOUR STORM DISTRIBUTION**
(for use in all areas of the City except the Traverse Ridge and Mountain Areas)

| **TIME** **Minutes from beginning of storm** | **Incremental Precipitation (inches)** | **Cumulative Precipitation/ (inches)** |
|---|---|---|
| 0 | 0.0000 | 0.000 |
| 5 | 0.0065 | 0.007 |
| 10 | 0.0065 | 0.014 |
| 15 | 0.0065 | 0.021 |
| 20 | 0.0065 | 0.028 |
| 25 | 0.0065 | 0.035 |
| 30 | 0.0065 | 0.042 |
| 35 | 0.0112 | 0.053 |
| 40 | 0.0112 | 0.063 |
| 45 | 0.0112 | 0.074 |
| 50 | 0.0112 | 0.085 |
| 55 | 0.0112 | 0.096 |
| 60 | 0.0112 | 0.107 |
| 65 | 0.1237 | 0.231 |
| 70 | 0.2372 | 0.467 |
| 75 | 0.0772 | 0.545 |
| 80 | 0.0391 | 0.583 |
| 85 | 0.0391 | 0.622 |
| 90 | 0.0391 | 0.661 |
| 95 | 0.0270 | 0.688 |
| 100 | 0.0270 | 0.715 |
| 105 | 0.0270 | 0.742 |
| 110 | 0.0270 | 0.769 |
| 115 | 0.0270 | 0.796 |

| TIME<br>Minutes from beginning of storm | Incremental Precipitation (inches) | Cumulative Precipitation/ (inches) |
|---|---|---|
| 120 | 0.0270 | 0.823 |
| 125 | 0.0112 | 0.834 |
| 130 | 0.0112 | 0.845 |
| 135 | 0.0112 | 0.856 |
| 140 | 0.0112 | 0.867 |
| 145 | 0.0112 | 0.877 |
| 150 | 0.0112 | 0.888 |
| 155 | 0.0065 | 0.895 |
| 160 | 0.0065 | 0.902 |
| 165 | 0.0065 | 0.909 |
| 170 | 0.0065 | 0.916 |
| 175 | 0.0065 | 0.923 |
| 180 | 0.0065 | 0.930 |

**TABLE 3B**
**SALT LAKE COUNTY 100-YEAR 3-HOUR STORM DISTRIBUTION**
(for use in all areas of the City except the Traverse Ridge and Mountain Areas)

| TIME<br>Minutes from beginning of storm | Incremental Precipitation (inches) | Cumulative Precipitation (inches) |
|---|---|---|
| 0 | 0.0000 | 0.000 |
| 5 | 0.0125 | 0.013 |
| 10 | 0.0125 | 0.027 |
| 15 | 0.0125 | 0.040 |
| 20 | 0.0125 | 0.054 |
| 25 | 0.0125 | 0.067 |
| 30 | 0.0125 | 0.080 |
| 35 | 0.0215 | 0.101 |
| 40 | 0.0215 | 0.122 |
| 45 | 0.0215 | 0.143 |
| 50 | 0.0215 | 0.164 |
| 55 | 0.0215 | 0.185 |
| 60 | 0.0215 | 0.205 |
| 65 | 0.2381 | 0.444 |
| 70 | 0.4565 | 0.899 |
| 75 | 0.1486 | 1.048 |

| **TIME**<br>**Minutes from beginning of storm** | **Incremental Precipitation (inches)** | **Cumulative Precipitation (inches)** |
|---|---|---|
| 80 | 0.0752 | 1.123 |
| 85 | 0.0752 | 1.197 |
| 90 | 0.0752 | 1.272 |
| 95 | 0.0519 | 1.324 |
| 100 | 0.0519 | 1.376 |
| 105 | 0.0519 | 1.428 |
| 110 | 0.0519 | 1.480 |
| 115 | 0.0519 | 1.532 |
| 120 | 0.0519 | 1.585 |
| 125 | 0.0215 | 1.605 |
| 130 | 0.0215 | 1.626 |
| 135 | 0.0215 | 1.647 |
| 140 | 0.0215 | 1.668 |
| 145 | 0.0215 | 1.689 |
| 150 | 0.0215 | 1.710 |
| 155 | 0.0125 | 1.723 |
| 160 | 0.0125 | 1.736 |
| 165 | 0.0125 | 1.750 |
| 170 | 0.0125 | 1.763 |
| 175 | 0.0125 | 1.777 |
| 180 | 0.0125 | 1.790 |

The Traverse Ridge Area is unique because of the interaction between suburban development and the Mountain Area. This interaction may result in a critical storm duration that is much longer than in the Urban Area. In the Traverse Ridge Area, a sensitivity analysis shall be performed using the 1-, 3-, 6-, 12- and 24-hour storm durations. The distribution for the 1- hour, 3-hour, and 6-hour storm durations is the Farmer-Fletcher 2nd Quartile Storm Distribution (see Table 4). Rainfall values for a given return period and storm duration are found by multiplying the table values for incremental and cumulative precipitation by the total storm depth (see design rainfall depths in Table 2). The time steps in Table 4 provide for 60 equal time steps to define the Farmer-Fletcher $2^{nd}$ Quartile Storm Distribution. The duration of each time step is found by dividing the total storm duration (minutes) by 60. For example, the time step for a 3-hour duration storm equals 3 minutes (3 hours multiplied by 60 minutes/hour divided by 60 total time steps).

**TABLE 4**

**FARMER-FLETCHER 2ND QUARTILE STORM DISTRIBUTION**

Dimensionless (for use in Traverse Ridge and Mountain Areas for the 1, 3, and 6 hour storm durations)

| TIME STEP | Incremental Precipitation/ Total Precipitation | Cumulative Precipitation/Total Precipitation |
|---|---|---|
| 1 | 0 | 0 |
| 2 | 0 | 0 |
| 3 | 0.002 | 0.002 |
| 4 | 0.002 | 0.004 |
| 5 | 0.002 | 0.006 |
| 6 | 0.002 | 0.008 |
| 7 | 0.002 | 0.01 |
| 8 | 0.002 | 0.012 |
| 9 | 0.003 | 0.015 |
| 10 | 0.003 | 0.018 |
| 11 | 0.004 | 0.022 |
| 12 | 0.005 | 0.027 |
| 13 | 0.008 | 0.035 |
| 14 | 0.009 | 0.044 |
| 15 | 0.009 | 0.053 |
| 16 | 0.013 | 0.066 |
| 17 | 0.017 | 0.083 |
| 18 | 0.02 | 0.103 |
| 19 | 0.024 | 0.127 |
| 20 | 0.029 | 0.156 |
| 21 | 0.033 | 0.189 |
| 22 | 0.034 | 0.223 |
| 23 | 0.035 | 0.258 |
| 24 | 0.038 | 0.296 |
| 25 | 0.039 | 0.335 |
| 26 | 0.045 | 0.38 |
| 27 | 0.052 | 0.432 |
| 28 | 0.054 | 0.486 |
| 29 | 0.054 | 0.54 |
| 30 | 0.054 | 0.594 |
| 31 | 0.052 | 0.646 |
| 32 | 0.045 | 0.691 |
| 33 | 0.04 | 0.731 |
| 34 | 0.035 | 0.766 |
| 35 | 0.03 | 0.796 |
| 36 | 0.022 | 0.818 |
| 37 | 0.02 | 0.838 |
| 38 | 0.018 | 0.856 |
| 39 | 0.016 | 0.872 |
| 40 | 0.014 | 0.886 |
| 41 | 0.012 | 0.898 |

| TIME STEP | Incremental Precipitation/ Total Precipitation | Cumulative Precipitation/Total Precipitation |
|---|---|---|
| 42 | 0.011 | 0.909 |
| 43 | 0.01 | 0.919 |
| 44 | 0.009 | 0.928 |
| 45 | 0.009 | 0.937 |
| 46 | 0.008 | 0.945 |
| 47 | 0.006 | 0.951 |
| 48 | 0.006 | 0.957 |
| 49 | 0.005 | 0.962 |
| 50 | 0.005 | 0.967 |
| 51 | 0.005 | 0.972 |
| 52 | 0.005 | 0.977 |
| 53 | 0.004 | 0.981 |
| 54 | 0.004 | 0.985 |
| 55 | 0.004 | 0.989 |
| 56 | 0.003 | 0.992 |
| 57 | 0.003 | 0.995 |
| 58 | 0.002 | 0.997 |
| 59 | 0.002 | 0.999 |
| 60 | 0.001 | 1 |

The distribution for the 12- and 24-hour storm is called the GBEA. Thirteen separate gauging stations in the Great Basin Experimental Area (GBEA) ranging in elevation from 5,500 feet to over 10,000 feet were maintained for varying periods of time from 1919 to 1965. Fifteen gauging stations were maintained in the Davis County Experimental Watershed ranging in elevation from 4,350 feet to 9,000 feet for varying periods of time between 1939 and 1968. After completing their analyses of the data, Farmer and Fletcher found "more than 50% of the storm rainfall depth occurs in 25% of the storm periods" and that "usually more than half of the total depth of rain is delivered as burst rainfall." Farmer and Fletcher developed design storm distributions which have become accepted by governmental entities including Salt Lake County and Davis County as the characteristic distributions for storms in Utah of short duration, meaning those generally less than six hours.

Farmer and Fletcher's work was expanded in 1985 to develop a longer duration rainfall distribution from the GBEA data (VHA, 1985). For the derivation of the design 24-hour rainfall event, a storm was defined "as a period of continuous or intermittent precipitation delivering at least 0.1 inches of rainfall during which time dry periods without rainfall did not exceed four hours." Storms having durations ranging from 20 to 28 hours were accepted to be representative of a 24-hour duration storm. The 24-hour duration storms were then screened to include only storms which contained rainfall meeting the burst criteria of having over 50% of the precipitation occurring in less than 25% of the time. Storms meeting the burst criteria were further categorized in accordance with which quartile of the storm the burst had occurred, i.e. the first, second, third or fourth quarter of the storm period. Identified storms were used to develop a 24-hour design storm distribution for use in Utah. A sensitivity analysis for all storm distributions developed shows the 3rd quartile storm distribution to produce the higher runoff peaks. The GBEA 3rd quartile storm distribution developed in 1985 includes a burst of rainfall with approximately 10% of the 24-hour total rainfall falling within a half-hour period. In a similar comparison, the SCS Type II distribution allows approximately 62% of the total precipitation to occur within the same period. Because the distribution is developed based on local data, the GBEA distribution is believed to be the best available storm distribution for Utah for storms lasting between six and 24 hours. The GBEA dimensionless storm distribution, which shall be followed in Draper City, is shown in Table 5. Values for a given return period and storm duration are found by multiplying the table values for incremental and cumulative precipitation by the total storm depth. The time steps in Table 5 provide for 48 equal time steps to define the GBEA design storm distribution. The duration of each time step is found by dividing the total storm duration by 48. For example, the time step for a 12-hour duration storm equals 15 minutes (12 hours multiplied by 60 minutes/hour divided by 48 total time steps).

**TABLE 5**
**GBEA STORM DISTRIBUTION**
Dimensionless (for use in the Traverse Ridge Area and Mountain Area)

| TIME STEP | Incremental Precipitation/ Total Precipitation | Cumulative Precipitation/Total Precipitation |
|---|---|---|
| 0 | 0 | 0 |
| 1 | 0.001 | 0.001 |
| 2 | 0.0025 | 0.0035 |
| 3 | 0.004 | 0.0075 |
| 4 | 0.0044 | 0.0119 |
| 5 | 0.0045 | 0.0164 |
| 6 | 0.0046 | 0.021 |
| 7 | 0.005 | 0.026 |
| 8 | 0.0058 | 0.0318 |
| 9 | 0.0062 | 0.038 |
| 10 | 0.0063 | 0.0443 |
| 11 | 0.0065 | 0.0508 |
| 12 | 0.007 | 0.0578 |
| 13 | 0.0075 | 0.0653 |
| 14 | 0.008 | 0.0733 |
| 15 | 0.009 | 0.0823 |
| 16 | 0.01 | 0.0923 |
| 17 | 0.011 | 0.1033 |
| 18 | 0.0115 | 0.1148 |
| 19 | 0.013 | 0.1278 |
| 20 | 0.014 | 0.1418 |
| 21 | 0.016 | 0.1578 |
| 22 | 0.019 | 0.1768 |
| 23 | 0.025 | 0.2018 |

| TIME STEP | Incremental Precipitation/ Total Precipitation | Cumulative Precipitation/Total Precipitation |
|---|---|---|
| 24 | 0.03 | 0.2318 |
| 25 | 0.05 | 0.2818 |
| 26 | 0.06 | 0.3418 |
| 27 | 0.065 | 0.4068 |
| 28 | 0.0675 | 0.4743 |
| 29 | 0.07 | 0.5443 |
| 30 | 0.069 | 0.6133 |
| 31 | 0.065 | 0.6783 |
| 32 | 0.05 | 0.7283 |
| 33 | 0.035 | 0.7633 |
| 34 | 0.028 | 0.7913 |
| 35 | 0.023 | 0.8143 |
| 36 | 0.021 | 0.8353 |
| 37 | 0.019 | 0.8543 |
| 38 | 0.018 | 0.8723 |
| 39 | 0.017 | 0.8893 |
| 40 | 0.0155 | 0.9048 |
| 41 | 0.015 | 0.9198 |
| 42 | 0.0145 | 0.9343 |
| 43 | 0.014 | 0.9483 |
| 44 | 0.013 | 0.9613 |
| 45 | 0.011 | 0.9723 |
| 46 | 0.01 | 0.9823 |
| 47 | 0.009 | 0.9913 |
| 48 | 0.0087 | 1 |

## STORM DRAINAGE MODELING METHOD

The HEC-1 or HEC-HMS model is chosen as the basic modeling platform for hydrology. Many programs include this platform as an optional method. The HEC-1 unit hydrograph method chosen was the SCS Dimensionless method and the HEC-1 loss method chosen was the SCS Curve Number method. The SCS Curve Number and Unit Hydrograph method utilizes three main parameters: curve number, percent impervious and lag time. The composite curve number is an area-weighted curve number based on all pervious and unconnected impervious areas. The method relies on the percent impervious input parameter to model the directly connected impervious area. The lag time for urban areas is calculated using methodology for determining time of concentration as described in the Natural Resources Conservation Service publication TR-55 “Urban Hydrology Manual”. Where undeveloped conditions exist, especially in mountain and canyon areas tributary to the City, the Simas and Hawkins “Lag Time Characteristics for Small Watersheds in the U.S” shall be followed. See ftp://ftp.wcc.nrcs.usda.gov/wntsc/H&H/hydrographs/lag.pdf and application detail below.

The following sub-basin characteristics shall be defined as described:

- The curve number is a composite curve number for all area not considered directly connected impervious area. This calculation can be accomplished in a spreadsheet using GIS or CAD determined area-types. Total impervious area for commercial areas and roadways is included with the directly connected impervious area. Residential areas, not including roads, are divided between pervious, directly connected impervious and unconnected impervious based on typical home determinations that are applied based on the number of individual homes in the subbasin. All remaining areas not included in the previous determinations are then included in with the pervious area. The total percent impervious (directly connected impervious area) and composite curve number for the remaining percentage are calculated and entered into the program.
- Curve numbers are based on the TR-55 tables 2-2a through 2-2d. Initial abstraction is defined as the amount of rainfall in inches that is lost before runoff begins and includes water retained in surface depressions, water absorbed by vegetation, evaporation and infiltration. HEC-1 computes the initial abstraction from CN if left blank.
- The Lag Time input line is the subbasin lag time in hours as calculated using the TR-55 time of concentration methodology converted to lag time. This is accomplished by partitioning the pervious and unconnected impervious area plane into sheet flow, shallow concentrated flow and channel flow including pipe flow.
- Where undeveloped conditions exist, especially in mountain and canyon areas tributary to the City, the Simas and Hawkins method shall be used for lag time determination. This method uses the regression equation:

  $$T_{lag} = 0.0051 \text{ x } \mathit{width}^{0.594} \text{ x } \mathit{slope}^{-0.150} \text{ x } S_{nat}^{0.313}$$

  where width (ft) is the watershed area divided by the watershed length, slope (ft/ft) is the ratio between the maximum difference in elevation and the longest flow-path length and $S_{nat}$ is the storage coefficient (in) used in the Curve Number (CN) method.

Detention basins shall be modeled using HEC-1/HEC-HMS methodology which requires a method such as Outflow Curve, Outflow Structures or Specified Release. These methods use storage-discharge, elevation-area-discharge, elevation-storage-discharge, elevation-area or elevation-storage tables. The calculation of these discharge relationships shall be determined based on outlet structure configuration, detention basin area, stage and volume relationships, and discharge rates as determined by orifice and weir flow calculations.

# DESIGN CRITERIA

The Design Criteria, like the Hydrologic Criteria, are selected from established, documented and well-tested methods. These methods have been proven to produce effective designs in many communities. A stormwater plan that includes the subsequently discussed methods and materials will provide an efficient and cost effective infrastructure.

## STREET DRAINAGE

Downhill Cul-De-Sacs and Sags in Street Profile Not at an Intersection: Downhill cul-de-sacs and dead-end streets which slope downhill to the end of the street are prohibited unless specifically authorized by the City Engineer. Sags in street profile which are not located at an intersection are prohibited unless specifically authorized by the City Engineer. The City Engineer may authorize it if it is impractical to grade a street to avoid sags at locations other than at street intersections and if a suitable surface overflow and drainage system designed for the 100-year storm runoff event is provided which has adequate access for maintenance. All-weather access roads of 15 feet minimum width and 15% maximum slope shall be provided to all structures including open channels, grade control structures, manholes, and junctions.

Encroachment Standards: During a storm or melting event, some runoff is typically conveyed within the street. This includes flow on the pavement, in the gutter, and in more severe events, along the sidewalk, park strip and in front yards. Flow may not be desirable in some of these areas, especially during smaller and more frequent storms. To identify the types of acceptable street drainage, the standards identified by the Urban Drainage and Flood Control District, Denver, Colorado shall be used for planning and design. These standards identify acceptable levels of street flow for initial (minor) and major storms for different types of streets. Tables 5, 6, and 7 below are taken from Urban Storm Drainage Criteria Manual - Volume I. For the minor storm, the street flow standards are included in Table 5 as follows:

**TABLE 5**

**PAVEMENT ENCROACHMENT STANDARDS FOR THE MINOR STORM**

| Street Classification | Maximum Encroachment |
|---|---|
| Local | No curb overtopping. Flow may spread to crown of street. |
| Collector | No curb overtopping. Flow spread must leave at least one lane free of water. |
| Arterial | No curb overtopping. Flow spread must leave at least one lane free of water in each direction but should not flood more than two lanes in each direction. |
| Freeway | No encroachment is allowed on any traffic lanes. |

The main objective for design for the minor storm event is that street inundation be small enough to allow safe vehicular movement on all streets during all times during the storm. Flood elevations should remain low enough that no damage to existing facilities occurs.

Urban Storm Drainage Criteria Manual - Volume I also provides encroachment standards for a major storm, such as the 100-year storm event. These standards are reproduced in Table 6:

**TABLE 6**

**STREET INUNDATION STANDARDS FOR THE MAJOR (i.e. 100-YEAR) STORM**

| Street Classification | Maximum Depth and Inundated Area |
|---|---|
| Local and Collector | Residential dwellings and public, commercial, and industrial buildings shall be no less than 12 inches above the 100-year flood at the ground line or lowest water entry of the building. The depth of water over the gutter flow line shall not exceed 18 inches. |
| Arterial and Freeway | Residential dwellings and public, commercial, and industrial buildings shall be no less than 12 inches above the 100-year flood at the ground line or lowest water entry of the building. The depth of water shall not exceed the street crown to allow for operation of emergency vehicles. The depth of water over the gutter flow line should not exceed 12 inches. |

The main objective for design for the major storm event is that buildings are not flooded and arterials and freeways remain passable to vehicles.

In addition to flow along the street, flows which cross the street need to be considered. Cross-street flow standards established by Urban Storm Drainage Criteria Manual - Volume I are provided in Table 7:

**TABLE 7**

**ALLOWABLE CROSS-STREET FLOW**

| **Street Classification** | **Minor Storm Flow** | **Major Storm Flow** |
|---|---|---|
| Local | 6-inches of depth in cross-pan. | 18-inches of depth above gutter flow line. |
| Collector | Where cross pans allowed, depth of flow should not exceed 6-inches | 12-inches of depth above gutter flow line. |
| Arterial / Freeway | None. | No cross flow. Maximum depth at upstream gutter on road edge of 12-inches. |

Cross street flow is allowed only for local streets and collector streets with cross pans. Large collectors, arterial streets and freeways shall not experience cross flows in either initial or major type storms.

Curb and Gutters: Curb and gutters, or gutters only when required for traffic safety, shall be provided for all urban streets to convey runoff. The minimum longitudinal street slope shall be 0.5% to provide an adequate slope for drainage. The cross street slope, from the street crown to the gutter, shall be at least 1%.

Manning's friction coefficient (*n*): Manning's Equation is used to predict the average velocity of flow in channels. Modified versions of the equation are commonly used to estimate open channel flow rates. The friction coefficient used in the equation varies considerably depending on the surface roughness of the conveyance channel. While it is theoretically possible for concrete or pavements to have a lower value, in practice it is unlikely that the coefficient will be less than $n = 0.016$ along the gutters and streets. This is the minimum $n$ value for use in Draper City. Larger values shall be used when required by the expected conditions.

Reduction Factor for Gutter Flow: As stormwater runoff is conveyed along a street, it frequently comes in contact with obstructions including cars, which slow its flow and reduce the street conveyance capacity (see discussion in Urban Storm Drainage Criteria Manual - Volume 1, pages 9 and 10). As a result, street flow capacity computations frequently over predict a street's conveyance ability. The Urban Storm Drainage and Flood Control District recommends, and it is a requirement in the City of Draper, that the estimated street conveyance capacity be reduced by a factor to account for the indicated flow disruptions. The reduction factor, which varies with street grade, is provided in Figure 3. A separate set of factors are provide for a minor and major event. This factor shall be multiplied by the calculated theoretical street capacity to define the allowable flow capacity.

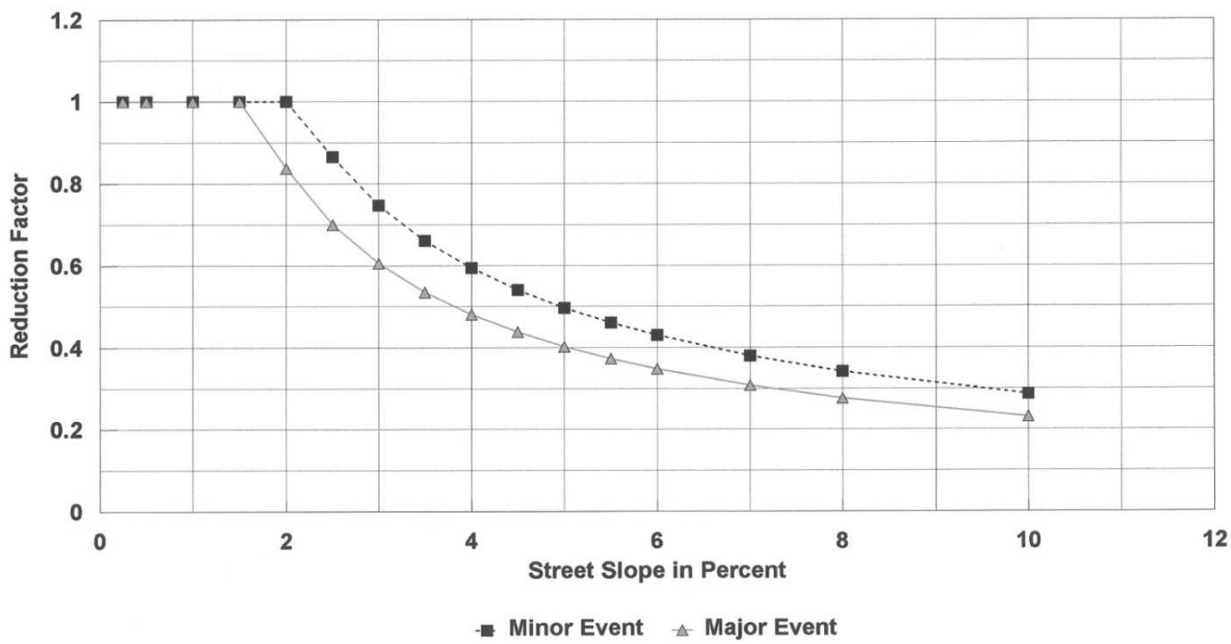



**Figure 3 (Figure ST-2 Drainage Criteria Manual) – Reduction Factor for Gutter Flow**

**STORM INLETS**

Inlet Capacity: Drainage system design within the Urban Area shall follow the methods described in Urban Drainage Design Manual Hydraulic Engineering Circular No. 22, produced by the Federal Highway Administration. However, inlet capacity for a single grate inlet shall be reduced by 50% to account for plugging. The inlet capacity of a single curb opening inlet shall be reduced by 10%. If multiple inlets occur in a series, the inlets' capacity shall be reduced by the factors provided in Table 8, taken from the Urban Storm Drainage Criteria Manual - Volume 1 included below.

**TABLE 8**

**CLOGGING COEFFICIENTS TO CONVERT CLOGGING FACTOR FROM SINGLE TO MULTIPLE UNITS (K)**

| **Number of Inlets** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **>8** |
|---|---|---|---|---|---|---|---|---|---|
| **Grate Inlet** | 1 | 1.5 | 1.75 | 1.88 | 1.94 | 1.97 | 1.98 | 1.99 | 2 |
| **Curb Opening Inlet** | 1 | 1.25 | 1.31 | 1.33 | 1.33 | N/A | N/A | N/A | N/A |

The clogging factor is determined as:

$$C = (C_o \times K) / N$$

C = Clogging Factor

$C_o$ = Clogging Factor for a Single Inlet (50% for Grate Inlet and 10% for a Curb Opening Inlet

K = Clogging Coefficient from Table 5

N = Number of Units (Inlets)

From the equation and Table 5, it can be observed that the percent of clogged area of the inlet is expected to be reduced as the number of total inlets in series increases.

**STORM DRAINS**

Design Standards: To provide an efficient storm drainage system with minimal maintenance requirements, the following design standards shall be observed:

- Minimum Pipe Size: When the storm drain pipe has a smooth non-corrugated interior, the minimum pipe size is 15 inches inside diameter. For pipe with a corrugated interior wall, the minimum pipe size is 18 inches inside diameter.

- Minimum Flow Velocity: For calculations which assume that the pipe is flowing full, a minimum velocity of 3-ft/s is required. This allows for a 2-ft/s velocity when the flow depth is 25% of the pipe diameter, thereby reducing the occurrence of sediment build-up within the pipe. See HEC-22 Section 7.2.4.

- Minimum Pipe Cover: The pipe cover for storm drains shall generally be three feet. Occasionally, specific site conditions may dictate the use of less cover. In these rare cases, the storm drain shall be designed to ensure that the structural integrity of the system is preserved. In no case shall the cover be less than one foot.

- Alignment: Generally, storms drains shall be installed directly between manholes with no curved alignment. In cases where the diameter of the storm drain is larger than four feet and where required by site conditions, curved storm drains may be considered.

- Balanced Hydraulic Design: Inlet capacity shall not be so great as to allow more water into the drainage facilities than they were designed to accommodate.

Conceptual Hydraulic Design: For conceptual level planning, hydraulic design may be completed using the Manning's Equation for uniform flow. The friction loss coefficient $n$ shall be increased to account for minor losses. The increase for minor losses shall be 0.002. For example, if the conceptual level design utilizes a friction loss coefficient of $n = 0.013$ before accounting for minor losses, the total friction coefficient after accounting for minor losses shall be $n = 0.015$.

Final Hydraulic Design: When completing a final design, a energy grade line evaluation shall be performed. The evaluation shall follow the procedures outlined in Chapter No. 7 of Urban Drainage Design Manual - Hydraulic Engineering Circular No. 22.

**STORM WATER QUANTITY CONTROL FACILITIES**

A typical trend along the Wasatch Front is for land use patterns to change toward increasingly dense uses. With increased density comes an increase in the proportion of land that is impervious. It is expected that the neighborhoods which make up Draper City will participate in this trend. These land use changes typically create conditions during rainfall and snow melt episodes where the volume and peak flow rates of runoff increase when compared to pre-development conditions. When increased runoff occurs, previously constructed and natural drainage ways may be unable to accommodate the flows. Flooding and related damage is more likely to occur. Commonly, communities address the concern of damage from increased runoff due to new development in one of the following ways:

- Enlarged Conveyance Facilities: One alternative is to upgrade existing inadequate facilities, or with regard to new development, require the installation of larger infrastructure.
- Stormwater Detention Facilities: This alternative allows storm water runoff to be stored and then released over time. During periods of high flow, water is collected and stored in basins and released over a great enough period of time that the downstream facilities are not overwhelmed.

DETENTION BASIN DESIGN STANDARDS: As a minimum the following design standards for detention basins shall be applied to all new detention facilities in Draper City.

- Detention Basin Storage Design Storms:
  - Traverse Ridge: Because storms of different sizes and return periods will flow into the detention facilities, it is important for them to be designed for a variety of conditions. It has been historically observed that a basin designed for one specific storm does not often effectively address storms of other return periods. Consequently, for the Traverse Ridge and Mountain areas, detention basin storage volumes shall be evaluated with at least three design storms: the 2-year, 10-year and 100-year storms. Storm duration sensitivity analyses are required to define the critical storm durations.
  - Urban Area (Salt Lake County): Detention basin storage volumes will be evaluated based on the Salt Lake County 10-year 3-hour design storm (see Table 3A).
- Detention Basin Release Rate Criteria
  - Traverse Ridge
    - 2-year 24-hour storm: capture the total runoff volume and release over a minimum of 48 hours and a maximum of 72 hours.
    - 10-year storm: Release at a rate as defined by a site specific hydrology analysis of pre-development conditions. Assume that the detention basin is full to the 2-year 24-hour storm runoff volume at the beginning of the 10-year detention design storm.
    - 100-year storm: Release at a rate as defined by a site specific hydrology analysis of pre-development conditions. Assume that the detention basin is full to the 2-year 24-hour storm runoff volume at the beginning of the 100-year detention design storm.
  - Urban Area: Release at a maximum flow rate of 0.1 cfs per acre in the design 10-year 3-hour storm event.
- Emergency Spillway: An emergency spillway shall be included in the design. The spillway shall be designed in such a manner as to protect impound embankments, nearby structures and surrounding properties. The elevation of the top of the embankment shall be a minimum of one foot above the water surface elevation when the emergency spillway is conveying the maximum design or emergency flow. The design height of the embankment shall be increased by at least 5 percent to account for settlement. The emergency spillway design flow shall be at least the 100-year peak inflow to the facility.

- Safety: Containment basins may attract people, especially children. They often create a safety hazard when the basin is readily accessible to the public and designed without a safety plan. Basin designs shall include side slopes of 3H:1V or less steep, and they may include secure fences, escape facilities and inlet and outlet structures which will not cause individuals to become drawn toward them or entrapped.

- Access: Maintenance access to the basins shall be provided. Access roads shall be provided to the outlet structure and to the detention basin floor. Required access includes heavy equipment access of 15 feet minimum width and 15% maximum slope to the basin floor, and all-weather access to the outlet facilities.

Further Discussion: These criteria and those presented below for stormwater retention facilities are further discussed in Urban Drainage Design Manual - Hydraulic Engineering Circular No. 22, Chapter 8.

Stormwater Retention Facilities: The City Engineer will determine if retention will be allowed for new construction. There are concerns with environmental factors such as mosquitoes and ground water contamination. The following guidelines are provided to assist with design if this alternative is chosen and allowed. A retention facility stores runoff without a surface or pipe outlet. During a time after the storm, the water infiltrates and evaporates. Because infiltration and evaporation rates can be small, basin volumes are usually rather large. The design of retention basins shall address the following items:

Long Term Infiltration Rate: Infiltration rates may appear to be adequate during infiltration rate testing and immediately after completion of the basin. However, leaves, other vegetative matter and fine grained sediments may build up on the basin's bottom and sides. This may reduce the infiltration rate. If these issues are not considered in the design, the basin may retain water for much longer than expected.

Water Budget: A mass balance evaluation shall be completed for the retention basin during a typical wet season. The purpose of this evaluation is to look at possible sources of inflow and outflow to see if the basin will function effectively over time. The mass balance shall look at precipitation inflow, infiltration and evaporation rates.

Emergency Spillway: An emergency spillway shall be included in the design. The spillway shall be designed in such a manner as to protect impound embankments, nearby structures and surrounding properties.

Safety: The safety discussion provided for detention basins shall be reviewed for retention basins also.

## EASEMENTS

Easements shall be provided with storm drainage facilities to facilitate maintenance. Storm drain easements shall have a minimum width of 15 feet. All-weather access roads of a minimum 15 feet wide and 15% maximum slope shall be provided to all structures including open channels, grade control structures, manholes, and junctions.

# REFERENCES

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# APPENDIX

# CITY OF DRAPER
# SITE DEVELOPMENT
# STORM DRAINAGE AND
# EROSION CONTROL
# PLAN SUBMITTAL REQUIREMENTS

# SITE DEVELOPMENT
# STORM DRAINAGE AND EROSION CONTROL
# PLAN SUBMITTAL REQUIREMENTS

## 1 REVIEW PROCESS

All subdivisions, re-subdivisions or any other development or redevelopment done within Draper City shall be required to submit drainage reports, plans, construction drawings, specifications and as-constructed information in conformance to the requirements of the Drainage Design Criteria and this Appendix.

The general requirements for the subdivision of land in Draper City and conditions requiring subdivision are set forth in the Draper City Municipal Code. Readers are referred to the Draper City Municipal Code for standards and procedures for the review and approval of subdivision plats.

A summary of submittals which are required of the developer to be submitted for Planning Commission and City Council review and approval include:

A. **Conceptual Level Drainage Control Plan**. This plan is to be submitted for review by the Draper City Flood Control Director for conceptual level feasibility.

B. **Preliminary Plan**. This plan is to be submitted for review and preliminary approval by Draper City Planning Commission and City Council.

C. **Final Drainage Control Plan**. The final drainage plan will be submitted subsequent to preliminary approval and must receive approval from both the Planning Commission and City Council. Review meetings shall be held with the developer prior to the preparation of the final drainage plan and again prior to the development of final construction details and documents to avert potential problems with final design. These meetings shall be held prior to formal submittal of the final plans to the Planning Commission and City Council.

D. **Requirements**. The requirements for each of the plans are found within the following sections of this Appendix:

| PLAN | SECTION |
|---|---|
| Conceptual Level Drainage Control Plan | 2 |
| Preliminary Drainage Control Plan | 3 |
| Final Drainage Control Plan | 4 |
| Construction Record Drawings and Certification | 5 |

## 2 CONCEPTUAL LEVEL DRAINAGE CONTROL PLAN

At the conceptual level the following general project information shall be provided for review and approval prior to the development of a Preliminary Plan:

A. **General Location and Description of Project**

1. Township, range, section, 1/4 section, subdivision, lot and block.
2. Major drainage ways and facilities.
3. Area in acres.
4. Proposed land use.

B. **Drainage Basins and Sub-basins**

Reference to major drainageway planning studies such as a flood hazard delineation report, major drainageway planning report, and flood insurance rate map.

C. **Design Concept**

1. Proposed drainage concept and how it fits existing drainage patterns.
2. Discussions of drainage problems including stormwater quality and potential solutions at specific design points.
3. Discussion of detention storage and outlet design.
4. Discussion of potential for low impact development.
5. Discussion of post construction stormwater management and best management practices for long-term control of stormwater pollutants.

D. **Identification of Potential Impacts to Public Drainage Systems**

## 3 PRELIMINARY DRAINAGE CONTROL PLAN

At the time of land zoning, rezoning, or proposal for development or redevelopment, a preliminary drainage control plan is required in advance of the final drainage report. Ten copies of the preliminary drainage control plan, prepared and signed by a professional engineer registered in the State of Utah, shall be submitted to the Planning Commission for review. Such plans shall be cleanly and clearly reproduced and be legible throughout. Blurred or unreadable portions of the plan will be deemed unacceptable and will require re-submittal. Incomplete or absent information may require re-submittal of the plan.

The purpose of a preliminary drainage control plan is to define on a conceptual level the nature of the proposed development or project and to describe all existing conditions and propose facilities needed to conform to the requirements of the Drainage Design Criteria.

Each preliminary drainage control plan shall provide the following report information and mapping. It is recommended that the plan prepared by the developer follow the general outline provided below to facilitate review.

A. **General Location and Description**

1. Location
   a. City, County, State Highway and local streets within and adjacent to the site, or the area to be served by the drainage improvements.
   b. Township, range, section, 1/4 section, subdivision, lot and block.
   c. Major drainage ways and facilities.
   d. Names of surrounding developments.
   e. Name of receiving waters.

2. Description of Property
   a. Existing ground cover, specifying type and vegetation.
   b. Area in acres.
   c. Existing major irrigation facilities such as ditches and canals.
   d. Proposed land use and ground cover.

B. **Drainage Basins and Sub-basins**

1. Major Basin Description
   a. Reference to major drainageway planning studies such as the ` Draper City Storm Drainage Master Plan, a flood hazard delineation report, major drainageway planning reports, and flood insurance rate maps.
   b. Major basin drainage characteristics, and existing and planned land uses within the basin.
   c. Identification of all nearby irrigation facilities that will influence or be influenced by the local drainage.

2. Sub-Basin Description

   a. Describe historic drainage patterns of the property.
   b. Describe offsite drainage flow patterns and impact on development under existing and fully developed basin conditions.

C. **Drainage Facility Design Criteria**

1. General Concept. Discuss the following:
   a. Proposed drainage concept and how it fits existing drainage patterns.
   b. How offsite runoff will be considered and how expected impacts will be addressed.
   c. Anticipated and proposed drainage patterns.
   d. Stormwater quantity and quality management concept and how it will be employed. The use of computer based models for the evaluation of

stormwater quality and quantity will not be universally required of new developments, although their use is recommended. Under site specific conditions where it is believed by the City Engineer that impacts from the development may unacceptably impact downstream water quality or quantity, use of models may be required.

e. Maintenance and maintenance access.
f. Describe the content of tables, charts, figures, plates, drawings and design calculations presented in the report.

2. Specific Details (Optional Information)
   a. Discussions of drainage problems, including stormwater quality, and solutions at specific design points.
   b. Discussion of detention storage and outlet design.
   c. Discussion of impacts of concentrating flow on downstream properties.

D. **Public Drainage Improvements**

If the project requires that drainage improvements be constructed that will be dedicated to and owned and maintained by Draper City, a preliminary plan and/or design of the public improvement must also be provided, obtained, or completed.

E. **Reference** all criteria, master plans, and technical information used in support of the concept.

F. **Preliminary Report Mapping**

1. The General location map shall show the following information and conform to the following standards:

   a. All drawings shall be 11” x 17” or 22” x 34”in size.
   b. Maps shall provide sufficient detail to identify drainage flows entering and leaving the development and general drainage patterns.
   c. The general location map should be drawn at a scale of 1" = 200' to 1" = 1000' and show the path of all drainage from the upper end of any offsite basins to the defined major drainage ways.
   d. Identify all major facilities, including irrigation ditches, existing detention facilities, stormwater quality facilities, culverts, and storm sewers downstream of the property along the flow path to the nearest major drainageway.
   e. Include basins, basin identification numbers, drainage divides, and topographic contours.

2. Floodplain Mapping:
   a. Provide a copy of any published floodplain maps such as flood hazard area delineation or flood insurance rate maps.

b. All major drainage ways shall have the defined floodplain shown on the report drawings.
c. Show all flood hazards from either shallow overland flows, side channels, or concentrated flows.
d. Show the location of the property in relation to the floodplain(s) and/or flood hazards.

3. Drainage Plan Mapping:
   a. Prepare at a scale of 1" = 20' to 1" = 200' on an 11" x 17" or 22" x 34" size drawing sheet.
   b. Provide existing topographic contours at 2-foot or less intervals. In mountainous areas, the maximum interval may be extended to five feet. Final plan approval at 1-foot contour intervals shall be shown for areas of little relief. The contours shall extend a minimum of 100-feet beyond the property lines.
   c. Show all existing drainage facilities within map limits including basin boundaries and sub-boundaries.
   d. Show conceptual major drainage facilities including proposed stormwater quality BMPs, detention basins, storm sewers, swales, riprap, and outlet structures in the detail consistent with the proposed development plan.
   e. Identify any offsite feature including drainage that influences the development.
   f. Show proposed drainage patterns and, if available, proposed contours.
   g. Provide a legend to define map symbols.
   h. Give the project name, address, engineering firm and seal, and date in the Title block in lower right corner.
   i. Show the north arrow, scale and available bench mark information and location for each benchmark.

## 4 FINAL DRAINAGE CONTROL PLAN

The final drainage control plan serves to define and expand the concepts shown in the preliminary drainage control plan and is sufficient of itself to assure conformance to the Drainage Design Criteria. The final report may be submitted at any point during the permitting and platting process but must be reviewed and approved prior to issuance of any permit.

Ten copies of the final drainage control plan shall be submitted to the Planning Commission. The plan shall be typed and bound on 8-1/2" x 11" paper with pages numbered consecutively. Drawings, figures, and tables shall be bound with the plan or contained in an attached pocket. The plan shall include a cover letter presenting the design for review prepared or supervised by a professional engineer licensed in the State of Utah.

The plan shall at a minimum address the following outline and contain the following applicable information. It is recommended the plan prepared by the developer follow the general outline provided below to facilitate review.

A. **General Location and Description**

1. Location
   a. Information as required for Preliminary Plans.
   b. Local streets within the adjacent to the subdivision.
   c. Easements within and adjacent to the site.

2. Description of Property
   a. Information as required for Preliminary Plans.
   b. General project description.
   c. Area in acres.
   d. General soil conditions, topography, and slope.
   e. Irrigation facilities.

B. **Drainage Basins and Sub-basins**

1. Major Basin Description
   a. Information as required for Preliminary Plans.
   b. Identification of all irrigation facilities within the basin that will influence or be influenced by proposed site drainage.

2. Sub-Basin Description
   a. Information as required for Preliminary Plans.

C. **Drainage Facility Design Criteria**

The design criteria used in the development of the drainage plan shall be clearly identified, including a discussion related to the use or implementation of any optional provisions intended by the developer or any deviation from the Drainage Design Criteria. Any deviation from the Drainage Design Criteria must be fully justified in the final design report. Development criteria shall consider and discuss the following:

1. Previous Studies and Specific Site Constraints
   a. Previous drainage studies for the site that influence or are influenced by the drainage design and how implementation of the plan will affect drainage and stormwater quality for the site.
   b. Potential impacts identified from adjacent drainage studies.
   c. Drainage impacts of site constraints such as streets, utilities, transit ways, existing structures, and development or site plan.

2. Hydrologic Criteria
   a. Design storm rainfall and its return periods.
   b. Runoff calculation methods.
   c. Detention discharge and storage calculation methods.
   d. Discussion and justification of other criteria or calculation methods used that are not presented in or referenced by the Drainage Design Criteria.

3. Hydraulic Criteria
    a. Identify various capacity references.
    b. Discussion of other drainage facility design criteria used that are not presented in these Drainage Design Criteria.

4. Stormwater Quality Criteria
    a. BMPs to be used for stormwater quality control.
    b. Identify, as appropriate, water-quality capture volume and drain time for extended-detention basins, retention ponds and constructed wetland basins.
    c. Identify, as appropriate, runoff volume and flow rates for design of water-quality swales, and wetland channels.
    d. Discussion of other drainage facility design criteria used that are not presented in these Drainage Design Criteria or other manuals referenced by Draper City.

5. Waivers from Criteria
    a. Identify provisions for which a waiver is requested.
    b. Provide justification for each waiver requested.

D. **Drainage Facility Design**

Discuss the following:

1. Existing and proposed drainage patterns.
2. Compliance with offsite runoff considerations.
3. Storm drain hydraulic grade line computation results and summary of required sizes.
4. Proposed stormwater quality management strategy.
5. The content of tables, charts, figures, plates, or drawings presented in the report.
6. Drainage problems encountered and solutions at specific design points.
7. Detention storage and outlet design.
8. Stormwater quality BMPs to be used.
9. Maintenance access and aspects of the design.
10. Easements and tracts for drainage purposes, including the conditions and limitations for use.

E. **Public Drainage Improvements**

If the project requires that drainage improvements be constructed that will be dedicated to and owned and maintained by Draper City, the following must also be provided, obtained, or completed:

1. Two sets of plans in 11” x 17” or 22” x 34” form for initial review.
2. An application to design, plan, construct, re-construct or remodel a public improvement to be provided to the Planning Commission.

3. A bond or letter of credit guaranteeing payment and performance prior to commencing with work on the project.
4. Upon completion of the project, a set of reproducible as-constructed plans, certified by a licensed engineer, before the bond or other guarantee can be released.
5. After approval of the initial review set, ten sets of plans which will be distributed for review by all affected City departments and utility companies. After comments are received and addressed, four final sets will be stamped as approved and returned to the design engineer for use by the contractor and owner.

The information required shall be in accordance with sound engineering principles, the technical provisions of any manuals where appropriate, these Drainage Design Criteria, and other applicable City ordinances, regulations, criteria or design guidelines. The plans may also be subject to review by outside agencies such as Salt Lake County, Utah County, Federal Emergency Management Agency, U.S. Army Corps of Engineers, Environmental Protection Agency, or other agencies as required. The plans shall be signed and sealed by a professional engineer registered in the state of Utah.

F. **Conclusions**

The proposed Drainage Facility Plan will be evaluated based upon the material and data submitted in accordance with these Drainage Design Criteria and the other manuals referenced by Draper City. The plan must evaluate the effectiveness of the drainage design in controlling damage from storm runoff, in removing pollutants from storm runoff, and its potential influence on downstream drainages.

G. **References** of all criteria and technical information used.

H. **Appendices** shall include all backup and supporting materials including:

1. Hydrologic computations including computer model input and output listings.
    a. Land use assumptions regarding adjacent properties.
    b. Initial and major storm runoff at specific design points.
    c. Historic and fully-developed runoff computations at specific design points.
    d. Hydrographs at critical design points.
    e. Time of concentration and runoff coefficients for each basin.
    f. Stormwater quality BMP sizing calculations including runoff adjustments for minimizing directly-connected impervious areas.

2. Hydraulic computations including computer model input and output listings.
    a. Culvert capacities.
    b. Storm sewer capacity, including energy grade line (EGL) and hydraulic grade line (HGL) elevations.
    c. Gutter capacity as compared to allowable capacity.
    d. Storm inlet capacity including inlet control rating at connection to storm system.

e. Open channel design.
f. Check and/or channel drop design.
g. Detention area/volume capacity and outlet capacity calculations for flood detention and water quality basins; depths of detention basins.
h. Wetland area and area/depth distribution for constructed wetland basins.
i. Infiltration rates and volumes for porous pavement or release rates where underdrains or infiltration is not possible.
j. Flow rates, velocities, longitudinal slopes and cross-sections for wetland channels and water quality swales.
k. Downstream/outfall system capacity to the Major Drainageway System.

## I. **Final Report Mapping**

1. General location map, including all items as identified for the Preliminary Plan.
2. Floodplain mapping, including all items as identified for the Preliminary Plan.
3. Drainage plan mapping, including those items identified for the development of the Preliminary Plan, and:
   a. Property lines, existing easements, and easements proposed for dedication, with purposes noted.
   b. Streets, indicating ROW width, flowline width, curb or roadside swale type, sidewalk, and approximate slopes.
   c. Existing drainage facilities and structures, including irrigation ditches, roadside ditches, crosspans, drainage ways, gutter flow directions, and culverts; also pertinent information such as material, size, shape, slope and locations.
   d. Proposed type of street flow, roadside ditch or swale, gutter, slope and flow directions, and crosspans.
   e. Proposed storm sewers and open drainage ways, including inlets, manholes, culverts, and other appurtenances, including riprap or other erosion protection.
   f. Proposed structural water-quality BMPs, their location, sizing, and design information.
   g. Proposed outfall point for runoff from the developed area and, if required, facilities to convey flows to the final outfall point without damage to downstream properties.
   h. Routing and accumulation of flows at various critical points for the initial and water-quality storm runoff events, and major storm runoff events.
   i. Volumes and release rates for detention storage and water-quality capture volume for facilities and information on outlet works.
   j. Location and water surface profiles or elevations of all previously defined floodplains affecting the property. If floodplains have not been previously published, they shall be defined and shown on the drainage plan.
   k. Location and measured or estimated elevations of all existing and proposed utilities affected by or affecting the drainage design.
   l. Routing of upstream offsite drainage flow through or around the development.
   m. Location of any improvements included in the appropriate or accepted outfall system plan, major drainage plan, and/or storm drainage plan.

n. Definition of flow path leaving the development through the downstream properties ending at a major drainageway or receiving water.

## J. **Final Construction Plans**

For on-site drainage improvements, the final construction plans in 11” x 17” or 22” x 34” form shall be submitted after approval of the Final Drainage Report. Ten sets of plans shall be submitted for approval. Upon approval, four sets, stamped and signed, will be returned to the design engineer for use by the contractor, owner and design engineer. However, before any construction work begins, appropriate bonds, letters-of-credit, or other surety as required shall be issued to Draper City. The final construction plans as a minimum and as appropriate shall include:

1. Plan and profile of proposed pipe installations, inlets and manholes with pertinent elevations, dimensions, type and horizontal control shown.
2. Property and right-of-way lines, existing and proposed structures, fences and other land features.
3. Plan and profile of existing and proposed channels, ditches swales, and on-site water-quality BMPs with construction details, cross-sections and erosion controls.
4. Detention and water quality (if separate) facility grading, trickle channels, if any, outlet and inlet location, cross-sections or contours sufficient to verify volumes.
5. Details of inlet and outlet control devices and of all structural components being constructed.
6. Maintenance access.
7. General overlot grading and the erosion and sediment control plan prepared in accordance with applicable provisions of these Drainage Design Criteria.
8. Areas of modular block porous pavement, if any, and installation details.
9. Landscaping and revegetation plans and details.
10. Proposed finish floor elevations of structures.
11. Relation of site to current and, if appropriate, modified floodplain boundaries.
12. A statement agreeing to maintain and operate all privately-owned facilities, if any, in a working manner and in accordance with the requirements of the Utah Department of Environmental Quality specified in the stormwater discharge permit issued to Draper City.
13. Signature and seal of the professional engineer preparing these plans.

Approval by Draper City does not constitute approval or the issuance of permits by the State of Utah, which approval and permits shall be obtained prior to initiating any construction activities on the site.

## 5 CONSTRUCTION RECORD DRAWINGS AND CERTIFICATION

Upon completion of construction, the professional engineer who prepared the design plans, or a professional engineer who assumes responsibility for the inspection if the design engineer is no longer available, shall provide a signed and sealed Certification of Inspection verifying that all work was performed in accordance with the approved plans and in compliance with all applicable criteria of the City and that any changes which occurred during construction are included in the record drawings. Special circumstances may require that record reproducible drawings of the drainage improvements also be provided. Certification of Inspection and construction record drawings, if required, will be required prior to the issuance of a final connection permit or the issuance of a Certificate of Occupancy.