Park City Storm Water Master Plan

Volume 2: Drainage Design Manual

Park City Municipal Corporation
Park City, Utah

Final for Review
June 9, 2015

Stanley Consultants INC.
100 Years
ENGINEERING A BETTER WORLD

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Respectfully submitted,

Stanley Consultants, Inc.

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Executive Summary

This drainage manual summarizes the drainage design criteria for new storm drain infrastructure or required storm drain improvements within Park City Municipal Corporation ("The City") administrative boundaries. This manual includes hydrologic, hydraulic, environmental protection methods, as well as the requirements for drainage design submittal packages for review and approval by The City.

The manual was prepared as part of the 2014 Park City Storm Water Master Plan. It provides guidance to developers and contractors on drainage design criteria and submittal package requirements for new storm drain infrastructure as well as improvements within the City. This manual also outlines environmental control measures and storm water ordinances required by the City.

This manual provides the approved hydrologic models for estimation of peak runoff rates: the Rational Method, National Streamflow Statistics (NSS), HEC-1/HMS and TR-55. Approved hydraulic analysis models provided are: HEC-RAS, HY-8, Culvert Master, StormCAD, Storm and Sanitary Sewer. Minimum storm water quality and erosion control guidelines are listed. The Park City Design Storm is the 90% confidence interval of the 10 and 100 year recurrence intervals for conveyance and detention respectively with Type II rainfall temporal distribution. The report lists the development and construction submittal process required of the developers prior to any new construction or improvements.

The following is a summary of the Park City Storm Drain Design Criteria:

- Recurrence interval, oil/water separators: 2 years
- Recurrence interval, conveyance: 10 years
- Recurrence interval, sag inlets: 50 years
- Recurrence interval, bridges & culverts: 50 years (minor streams)
- Recurrence interval, bridges & culverts: 100 years (major streams)
- Recurrence interval, detention: 100 years
- Recurrence interval, retention: 500 years

• Allowable discharge:	Pre-development flow
• Approved models: (Table 2-3)	Rational Method, NSS, HEC-1/HMS, TR-55
• Time of Concentration:	Use relevant equation
• Lag Time:	0.6 x time of concentration
• Storm temporal distribution:	Type II
• Minimum storm drain pipe diameter:	15 inches
• Minimum cover for RCP:	18 inches (Table 3-7)
• Minimum cover for non-RCP, Rigid Pvt:	18 inches (Table 3-7)
• Minimum cover for non-RCP, Flexible Pvt:	24 inches (Table 3-7)

- For precipitation data, use upper bound of the 90% confidence interval – NOAA Atlas 14 Exceptions may be allowed if approved by the City Engineer.

• HGL – maximum design storm	> 1 foot below finished grade at all times
• Recommended water velocity	3.5 feet/second
• Maximum water velocity	10 feet/second
• Infrastructure design life	50 years
• Storm duration	Application/Model dependent, 12 hour.
• Detention storm duration	Maximum detention volume

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Section 1

1. Acronyms & Abbreviations

AADT:	Annual Average Daily Traffic
BMP:	Best Management Practice
CAD:	Computer Aided Design
CFS:	Cubic Feet per Second
CI:	Confidence Interval
CN:	Curve Number
CPP:	Corrugated Plastic Pipe
DWQ:	Division of Water Quality
EPA:	Environmental Protection Agency
FEMA:	Federal Emergency Management Agency
FHWA:	Federal Highway Administration
FIRM:	Flood Insurance Rate Map
GIS:	Geographic Information System
HGL:	Hydraulic Grade Line
HUC:	Hydrologic Unit Code
IDF:	Intensity-Duration-Frequency
MS4:	Municipal Separate Storm Sewer System
NAD:	North American Datum
NAVD:	North American Vertical Datum
NGVD:	National Geodetic Vertical Datum
NOAA:	National Oceanic and Atmospheric Administration

NRCS:	Natural Resources Conservation Service - Formerly Soil Conservation Service (SCS)
NSS:	National Streamflow Statistics
PCDS:	Park City Design Storm
PE:	Polyethylene
PVC:	Polyvinyl Chloride
ROW:	Right Of Way
SIC:	Standard Industrial Classification
SWE:	Snow Water Equivalent
SWPPP:	Storm Water Pollution Prevention Plan
TMDL:	Total Maximum Daily Loads
UDOT:	Utah Department of Transportation
UPDES:	Utah Pollution Discharge Elimination System
USGS:	United States Geological Survey
USWAC:	Utah Storm Water Advisory Committee

Section 2

2. Hydrologic Methods

2.1 Purpose

The purpose of this section is to describe the hydrologic methods that are accepted for storm water design projects for Park City Municipal Corporation. It is not the intent of this manual to replace engineering judgment in design of storm water facilities.

2.2 Rainfall Runoff Modeling

Modeling is usually done assuming an ideal or worst probable case storm. Continuous simulation of rainfall events is generally more appropriate, accurate and closer to reality to represent a rainfall-runoff event. However, for ease of implementation, single event modeling is typically used to model rainfall-runoff cases. For this reason, a "design storm" is utilized to best match real-life conditions

2.3 Design Storm

In selecting a design storm, a balance is needed between the level of protection and project cost. A storm drain system can be designed for large storms, but may not be affordable. A design storm needs to be selected taking into consideration the applicability and economic scale.

A design storm needs to:

- Represent storms in the location
- Be used in a reliable, applicable and economical design

Selecting a design storm to best represent specific conditions of an area of interest are generally based on the following:

- Accepted standards (regional, state, county standards). These standards are typically based on experience.
- Field calibration (calibration study covering flow and volumes at multiple points)
- Empirical (worst case or most economical)

This section is focused on the hydrologic characteristics of the Park City Design Storm (PCDS), including intensity, duration, and frequency.

2.3.1 Intensity

The intensity used for design is determined using the Park City specific Intensity-Duration-Frequency curves shown below (Figure 2-1). The upper bound of the 90% confidence interval, provided by NOAA, is to be used in the design of storm water facilities in Park City. Values of these curves and depths of respective storms are also included in Appendix A.

Intensity and depth values were obtained from NOAA's National Weather Service – Precipitation Frequency Data Server (http://hdsc.nws.noaa.gov/hdsc/pfds/pfds_map_cont.html?bkmrk =ut) for the "Park City Radio" station with Site ID 42-6648.

2.3.1 Duration

The duration of the storm depends on the rainfall runoff mathematical model and modeling approach. As an example, multiple storm durations are necessary to estimate the maximum detention volume required for the same intensity and frequency in the same project area. The use of the Modified Rational Method is recommended.

For hydrologic and hydraulic models that require a precipitation depth and storm duration, 12-hour storm duration is to be used to estimate the precipitation depth.

2.3.2 Time of Concentration (T_c)

The time of concentration (T_c) and the lag time are the most commonly used parameters in urban hydrology to determine storm intensities for design purposes. T_c is defined as the period required for water to travel from the most hydraulically distant point of the watershed to the point of interest. The time of concentration shall be calculated for each sub-basin and it can be estimated from a single formula, or as the sum of travel times within two or three segments of flow regimes: i.e. sheet flow, shallow concentrated and open channel. Following is a list of approved formulae for the estimation of T_c:

- NRCS (formerly SCS) lag time
- Technical Release (TR-55), sheet flow
- Technical Release (TR-55), shallow concentrated flow
- Technical Release (TR-55), open channel flow
- Kirpich (Asphalt, bare earth, grass)
- Kerby

Most hydrologic and hydraulic modeling software packages have these equations built in. No minimum time of concentration is set.

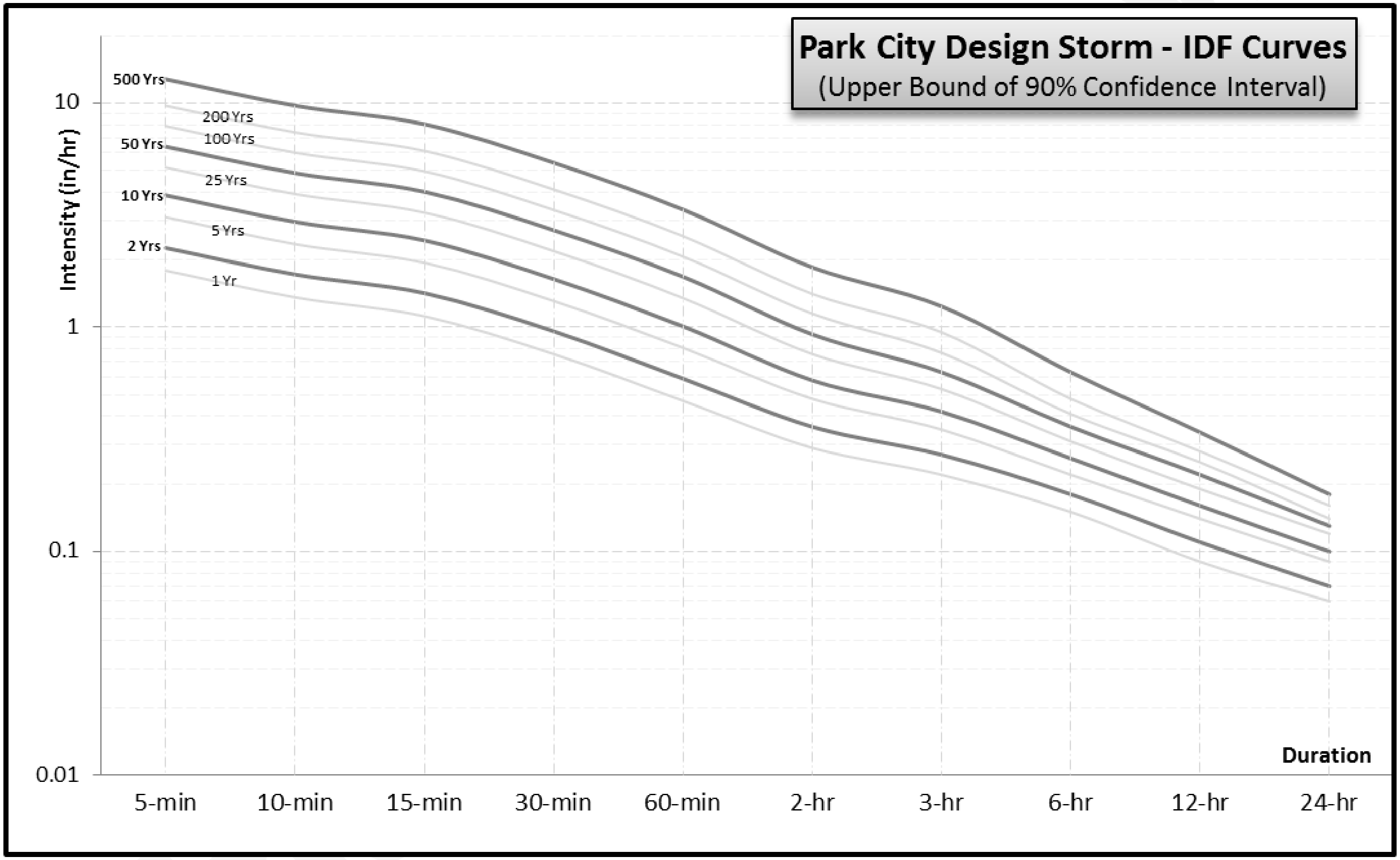

Figure 2-1: Park City Design Storm - IDF Curves (90% CI Upper Bounds) – Source NOAA Atlas 14

Table 2-1: Park City Design Storm (PCDS).

Duration	Frequency				
	2 Year	10 Year	50 Year	100 Year	500 Year
5 min	2.26	3.88	6.4	7.9	12.8
7 min	2.04	3.51	5.79	7.14	11.58
10 min	1.72	2.95	4.87	6.01	9.74
15 min	1.42	2.44	4.02	4.96	8.05
30 min	0.96	1.64	2.71	3.34	5.42
60 min	0.59	1.01	1.68	2.07	3.35
2 hour	0.36	0.58	0.93	1.15	1.85
3 hour	0.27	0.42	0.63	0.77	1.24
6 hour	0.18	0.26	0.36	0.41	0.63
12 hour	0.11	0.16	0.22	0.25	0.34
24 hour	0.07	0.1	0.13	0.14	0.18

2.3.3 Frequency

PCDS frequency varies depending on the application and is determined using the following table (Table 2-2). Sag inlets are inlets located in local low points.

Table 2-2 Design Storm Recurrence Interval

Oil/Water Separators	Conveyance	Sag Inlets, Bridges & Culverts	Detention	Retention
2 Year	10 Year	50 Year	100 Year	500 Year

Conveyance includes intakes, catch basins, storm sewers, culverts, swales and ditches. Detention, retention includes artificial ponding areas, detention ponds and created wetlands.

2.3.4 Temporal Distribution

PCDS is based on NRCS Type II temporal distribution (Figure 2-2). Values for NRCS Type II rainfall distribution are included in Appendix A.

2.4 Land Use

The latest City zoning map shall be used in coordination with other sources for upper catchment land use. Latest land use and zoning maps can be obtained from the City and other federal or state agencies. The Park City land use and latest zoning are available in hard copy and GIS format.

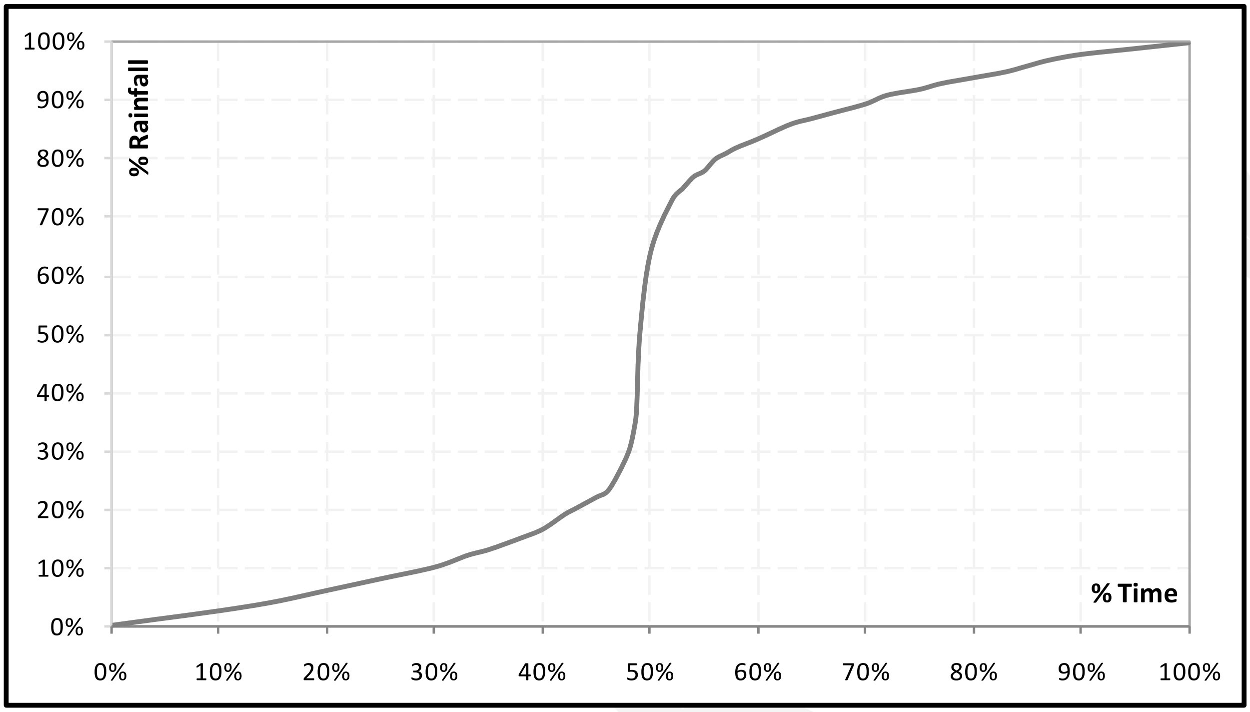

Figure 2-2: NRCS Type II Storm Temporal Distribution

2.5 Soil Data Set

Most current soil data set can be obtained from the City and other federal or state agencies. The soil type, along with the hydrologic soil group layer, is available in hard copy and GIS format. Geotechnical reports should be used to support the use of different soil types.

2.6 Allowable Discharge

All new developments or redevelopment must not release storm water more than pre-development flows for the 10-, 100- and 500-year storms.

2.7 Hydrological Models

The following is a list of the approved models to model rainfall runoff within Park City (Table 2-3). Any variation from these models must be pre-approved by the City Engineer.

Table 2-3: Approved Hydrologic Models.

Method/Model	Area Applicability	Remarks
Rational Method	Basin area < 300 acres*	Mostly urban areas
NSS	Depending on region/equation	Mostly rural areas
HEC-1/HMS	Any basin area	Urban/rural areas
TR-55	Total drainage area < 25 mi^2	Mostly urban areas

* UDOT Roadway Drainage Manual

2.7.1 Rational Method

The Rational Method, and its variations, is the most commonly used model to estimate peak runoff, while the Modified Rational Method is used to estimate the peak detention volume.

$$Q = C * i * A \qquad \text{(Equation 1)}$$

Where;
Q: Peak flow (cfs)
C: Runoff Coefficient (-).
i: Design storm intensity (in/hr)
A: Area of drainage basin (ac)

The Runoff Coefficient is used based on the following table (Table 2-4):

Table 2-4: Runoff Coefficient Values.

Drainage Area	Park City Zoning	Runoff Coefficient
Business		
Downtown areas		0.70 – 0.95
Neighborhood areas		0.50 – 0.70
Residential:		
Single-family areas		0.30 - 0.50
Multi-units, detached		0.40 - 0.60
Multi-units, attached		0.60 – 0.75
Suburban		0.25 – 0.40
Apartment dwelling areas		0.50 – 0.70
Industrial:		
Light areas		0.50 – 0.80
Heavy areas		0.60 – 0.90
Parks, cemeteries		0.10 - 0.25
Playgrounds		0.20 – 0.40
Railroad yard areas		0.20 – 0.40
Unimproved areas		0.10 – 0.30
Lawns:		
Sandy soil, flat, < 2%		0.05 - 0.10
Sandy soil, average, 2 – 7%		0.10 – 0.15

Drainage Area	Park City Zoning	Runoff Coefficient
Sandy soil, steep, > 7%		0.15 – 0.20
Heavy soil, flat, < 2%		0.13 – 0.17
Heavy soil, average, 2 – 7%		0.18 – 0.22
Heavy soil, steep, > 7%		0.25 – 0.65
Streets:		
Asphaltic		0.70 – 0.95
Concrete		0.80 – 0.95
Brick		0.70 – 0.85
Drives and walks		0.75 – 0.85
Roofs		0.75 – 0.95

The intensity is determined from the IDF curves in Figure 2-1 and Table 2-1. It must be noted that to design conveyance structures, maximum peak discharge for a given return period must be determined and used. To determine the size of the storage facility, maximum volume is determined using the Modified Rational Method.

2.7.2 National Streamflow Statistics (NSS)

This is the USGS regression equations formerly known as the National Flood Frequency (NFF). Starting with version 4.0 in December 2006, the updated NSS has replaced the NFF equations. Because of the nature of regression, it is always advisable to download the most current version and database prior to use. The current version on the date of this report is 6.1 with updates posted on 10/07/2014.

For Park City, equation of the geo-hydrologic region #1 shall be used. The equation is applicable for mostly rural areas with a basin area between 3.62 to 390 square miles and it requires two input parameters: drainage area and mean basin elevation.

2.7.3 HEC-1/HMS

After terrain processing, delineating watersheds and streams, the main required hydrologic parameters for HEC-1/HMS are categorized into five groups: precipitation, loss method, transform method, base flow and river routing.

1. Precipitation: as outlined in Section 2.3

2. Loss Method: The NRCS Curve Number method is the default loss method. Values for average antecedent runoff conditions are included in Table 2-8. Adjustment for dry or wet conditions can be estimated from Table 2-9. The GIS-based hydrologic soil group shall be determined using the NRCS STATSGO data set which can be obtained from NRCS, EPA and the City. The latest available land use data set can be obtained from EPA, USGS and the City (the soil classification and the land use classification covering the geographic area of the City is available for a nominal charge). However, it is the sole responsibility of the developer to verify that the data set obtained is most appropriate for hydrologic modeling purposes. Newly developed areas shall be merged

into the latest land use data set. The modeler shall take the directly-connected areas into consideration by incorporating the anticipated percentage of these areas into the model. Directly-connected areas are those with an impervious surface with all precipitation running off with no infiltration, interception or other losses.

The composite Curve Number is best calculated using a GIS approach. However, spreadsheets may be used to estimate an approximate value for the area-based composite Curve Number for each sub-basin using the actual drainage areas and values from Table 2-8 and Table 2-9.

3. Transform Method: Clark Unit Hydrograph or the NRCS Unit Hydrograph methods are accepted as the transform method. The lag time can be calculated using built-in different methods as applicable to the watershed at hand.

4. Base Flow: To estimate the constant monthly base flow (Table 2-5, Table 2-6 and Table 2-7), recession methods shall be used (unless a 2-D model is implemented, in which case, the linear reservoir method can be used). Values in Table 2-5, Table 2-6 and Table 2-7 are to be used for the respective watersheds. For example, unit base flow values in Table 2-5 shall be used for estimating base flow in watersheds within the McLeod Creek watershed. Similarly, unit base flow values in Table 2-7 shall be used for estimating base flow in watersheds within the Silver Creek or Poison Creek watersheds. Values in these tables are listed on a unit base flow basis. These unit values shall be multiplied by the area of modeled watershed to obtain the respective base flow. Maximum base flow shall be used as applicable.

5. Flood Routing: Muskingum or Muskingum-Cunge methods shall be used for stream routing. Routing parameters are automatically computed by the program, based on the geo-morphologic characteristics of the watershed. Manning roughness shall be used from Table 3-2 and Table 3-3.

Table 2-5: Monthly Average Base Flow for McLeod Creek – USGS Station 10133600.

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Average Base Flow (cfs)	4.54	5.22	6.29	9.35	16.75	23.71	13.29	6.72	5.04	4.39	5.32	4.09
Unit Base Flow (cfs/mi^2)	0.516	0.593	0.715	1.063	1.903	2.694	1.510	0.764	0.573	0.499	0.605	0.465

Table 2-6: Monthly Average Base Flow for East Canyon Creek – USGS Station 10133650.

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Average Base Flow (cfs)	4.66	7.38	13.86	24.31	31.69	29.99	10.12	5.26	3.40	4.73	5.95	5.07
Unit Base Flow (cfs/mi^2)	0.111	0.175	0.329	0.577	0.753	0.712	0.240	0.125	0.081	0.112	0.141	0.120

Table 2-7: Monthly Average Base Flow for Silver Creek – USGS Station 10129900.

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Average Base Flow (cfs)	2.18	2.38	4.08	6.61	5.61	5.69	2.50	1.42	1.22	1.53	1.94	2.00
Unit Base Flow (cfs/mi^2)	0.125	0.137	0.234	0.380	0.322	0.327	0.144	0.082	0.070	0.088	0.111	0.115

Table 2-8: Runoff Curve Numbers – Average Runoff Conditions*.

Cover Type and Hydrologic Condition	Curve Numbers[1] for Hydrologic Soil Groups				
	Average % Impervious Area	A	B	C	D
Fully developed urban areas (vegetation established)					
Open space (lawns, parks, golf courses, cemeteries, etc.):					
Poor condition (grass cover < 50%)		68	79	86	89
Fair condition (grass cover 50% to 75%)		49	69	79	84
Good condition (grass cover > 75%)		39	61	74	80
Impervious areas:					
Paved parking lots, roofs, driveways, etc. (excluding right-of-way)		98	98	98	98
Streets and roads:					
Paved curbs and storm drains (excluding right-of-way)		98	98	98	98
Paved open ditches (including right-of-way)		83	89	92	93
Gravel (including right-of-way)		76	85	89	91
Dirt (including right-of-way)		72	82	87	89
Western desert urban areas:					
Natural desert landscaping (pervious areas only)		63	77	85	88
Artificial desert landscaping (impervious weed barrier, desert shrub with 1- to 2- in sand or gravel mulch and basin borders)		96	96	96	96
Urban districts:					
Commercial and business	85	89	92	94	95
Industrial	72	81	88	91	93
Residential districts by average lot size:					
0.12 acres or less (town houses)	65	77	85	90	92
0.25 acres	38	61	75	83	87
0.33 acres	30	57	72	81	86
0.5 acres	25	54	70	80	85
1.0 acres	20	51	68	79	84

Cover Type and Hydrologic Condition	Curve Numbers[1] for Hydrologic Soil Groups				
	Average % Impervious Area	A	B	C	D
2.0 acres	12	46	65	77	82
Developing urban areas:					
Newly graded areas (previous areas only, no vegetation)		77	86	91	94
Undeveloped areas:					
Pasture –grassland continuous forage for grazing					
Poor: < 50% ground cover or heavily grazed with no mulch		68	79	86	89
Fair: 50% to 75% ground cover and not heavily grazed		49	69	79	84
Good: > 75% ground cover and lightly or only occasionally grazed		39	61	74	80
Meadow – continuous grass-protected from grazing and generally mowed for hay		30	58	71	78
Brush – brush-weed-grass mixture with brush the major element					
Poor: < 50% ground cover		48	67	77	83
Fair: 50% to 75% ground cover		35	56	70	77
Good: > 75% ground cover		30	48	65	73
Woods – grass combination (orchard or tree farm) [2]					
Poor: Hydrologic Condition		57	73	82	86
Fair: Hydrologic Condition		43	65	76	82
Good: Hydrologic Condition		32	58	72	79
Woods					
Poor: Forest litter, small trees & brush are destroyed by heavy grazing or regular burning		45	66	77	83
Fair: Woods grazed but not burned, and some forest litter covers the soil		36	60	73	79
Good: Woods protected from grazing; litter and brush adequately cover soil		30	55	70	77
Farmsteads – buildings, land, driveways and surrounding lots		59	74	82	86

* Source: UDOT Roadway Drainage Manual
1 Average antecedent moisture condition and initial abstraction $I_a = 0.2S$
2 CNs shown were computed for areas with 50% (pasture) cover. Other combinations of conditions may be computed from CNs for woods and pasture.

Table 2-9: Antecedent Runoff Conditions (ARC) Adjustment for CN Values.

CN Value for ARC II	Corresponding CN Value	
	ARC I (Dry)	ARC III (Wet)
100	100	100
95	87	98
90	78	96

CN Value for ARC II	Corresponding CN Value	
	ARC I (Dry)	ARC III (Wet)
85	70	94
80	63	91
75	57	88
70	51	85
65	45	82
60	40	78
55	35	74
50	31	70
45	26	65
40	22	60
35	18	55
30	15	50
25	12	43
20	9	37
15	6	30
10	4	22
5	2	13

The dry antecedent runoff conditions (Table 2-9) may only be used with prior written approval from the City Engineer. These conditions will severely reduce the estimated runoff and may be used for reference only and to estimate low flow conditions. The wet moisture conditions (Table 2-9) may be used to model rain on snow, successive storm events, or used for cold climate hydrology (Section 2.8).

2.7.4 Technical Release 55 (TR-55)

Technical Release 55 (TR-55) is the NRCS urban hydrology model for small watersheds. After terrain processing, and delineating watersheds and streams, the main hydrologic parameters required for TR-55 are categorized into three groups: precipitation, rainfall distribution and loss method.

Precipitation depths are obtained from the Park City Design Storm (Section 2.3) and the NRCS 24-hour storm type II (Figure 2-2). Curve number values from Table 2-8 and Table 2-9 shall be used to estimate peak flows using the NRCS Curve Number method. Time of concentration shall be computed as indicated in TR-55 or any modeling interface (NRCS, 2002).

2.8 Cold Climate Hydrology

Figure 2-3 shows the precipitation depth and snow water equivalent for the water year 2010/2011 in the Upper Weber River Basin, Summit County. Similar data for other stations and water years may be obtained from the SNOTEL website (NRCS, 2011).

2.8.1 Snow Depth & Snow Water Equivalent (SWE)

Table 2-10 lists average monthly snow fall depth for Park City and Snyderville meteorological stations. Snyderville station (40.7039°N, 111.537°W) has records with the average values obtained for the 1993-2011 period. Park City station (40.6706°N, 111.508°W) has records from 1992 to 2007 with average values obtained for the entire period. Snow water equivalent is a value representing the amount of water in the snowpack. It can be expressed by depth of theoretical rainfall or by percentage of snow depth. NRCS measures SWE at many SNOTEL sites (NRCS, 2011)

Table 2-10: Average Monthly Snow Fall Depth in Park City (Source: Utah State University).

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Snyderville Station (in)	33.9	31.3	23.5	16.1	4.3	0.0	0.0	0.0	0.7	7.2	21.3	32.0	170
Park City Station (in)	25.0	22.2	14.8	7.8	2.5	0.0	0.0	0.0	0.6	2.8	16.9	17.1	110

2.8.2 Snowmelt Runoff

The average annual snowfall in Park City is approximately 170 inches and approximately 240 inches annual in extreme years. Snowmelt and refreezing can lead to drainage infrastructure problems, including freezing of sewers and clogging of inlets. During spring, the accumulated snow melts over a short period of time (2-6 weeks), resulting in a large volume of snowmelt runoff (i.e. spring runoff). Park City does not require detailed snowmelt modeling and evaluation as part of new or redevelopment design. Spring runoff generally begins in late April and progresses into May and the first part of June. This spring runoff can produce large peak flows. Cold climate sizing should include the base flow as indicated above or the base flow calculated for the area under consideration.

2.8.3 Cold Climate Adjustment

- Do not submerge inlet pipes into permanent pools to avoid causing pipe ice blockages that could damage pipes or cause upstream flooding.
- Slope inlet pipes so that they have a minimum slope of 1% to prevent standing water that could freeze
- Place underdrains and outlet pipes at least a foot below the frost line, and increase their diameter by at least one pipe size.
- When perforated pipes are used, the minimum opening diameter should be one-half inch, and have a minimum pipe diameter of at least six inches.
- Angle trash racks to prevent ice formation

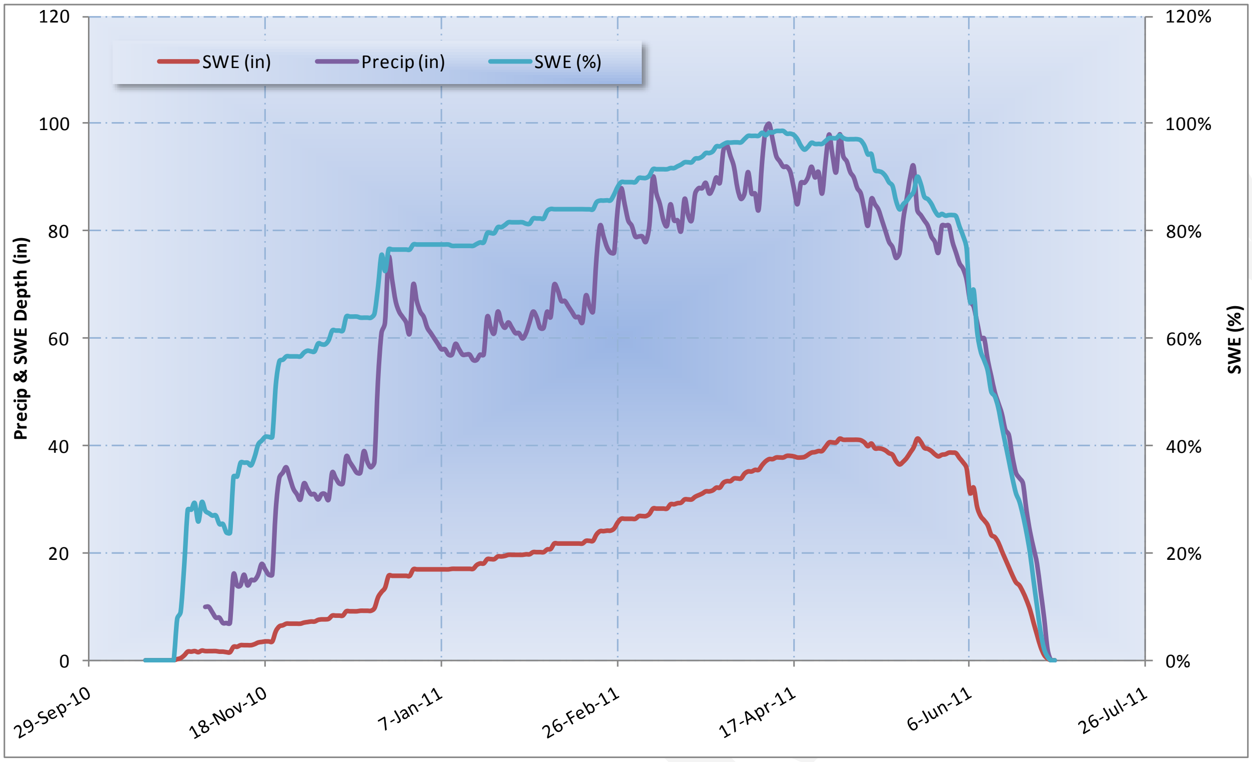

Figure 2-3: Precipitation & SWE, Upper Weber River Basin, Summit County – 2010/2011 Water Year (NRCS, 2011)

2.9 Offsite Modeling

Runoff from offsite areas shall be determined assuming the basin is fully developed as determined by the City's planning department. If such information is not available, developers must use the most current land use information available.

2.10 Storm Drain Design Criteria Summary

The design criteria listed in this manual represents the minimum requirements. These criteria will be revised as necessary. Developers, contractors and interested parties are encouraged to review the most current version of design criteria.

- Recurrence interval, oil/water separators: 2 years
- Recurrence interval, conveyance: 10 years
- Recurrence interval, sag inlets: 50 years
- Recurrence interval, bridges & culverts: 50 years (minor streams)
- Recurrence interval, bridges & culverts: 100 years (major streams)
- Recurrence interval, detention: 100 years
- Recurrence interval, retention: 500 years
- Allowable discharge: Pre-development flow

- Approved models: (Table 2-3) — Rational Method, NSS, HEC-1/HMS, TR-55
- Time of Concentration: — Use relevant equation
- Lag Time: — 0.6 x time of concentration
- Storm temporal distribution: — Type II
- Minimum storm drain pipe diameter: — 15 inches
- Minimum cover for RCP: — 18 inches (Table 3-7)
- Minimum cover for non-RCP, Rigid Pvt: — 18 inches (Table 3-7)
- Minimum cover for non-RCP, Flexible Pvt: — 24 inches (Table 3-7)
- For precipitation data, use upper bound of the 90% confidence interval – NOAA Atlas 14
- Exceptions may be allowed if approved by the City Engineer.
- HGL – maximum design storm — > 1 foot below finished grade at all times
- Recommended water velocity — 3.5 feet/second
- Maximum water velocity — 10 feet/second
- Infrastructure design life — 50 years
- Storm duration — Application/Model dependent, 12 hour.
- Detention storm duration — Maximum detention volume

Section 3

3. Hydraulic Methods

3.1 Storm Drain Facilities

All existing storm drain facilities within the project site shall be sized based on current conveyance, as needed and determined by the City.

All storm water facilities shall be located within the street right-of-way or a designated easement.

3.2 Roadway Drainage

3.2.1 Curb and Gutter

Allowable gutter spread is indicated in Table 3-1.

Table 3-1: Allowable Gutter Spread*.

Roadway Classification	Design Frequency (yr)	Allowable Spread
High Volume		
< 45 mph	10	Shoulder + 3 ft
> 45 mph	10	Shoulder
sag	50	Shoulder + 3 ft
Collector		
< 45 mph	10	½ Driving Lane
> 45 mph	10	Shoulder
sag	10	½ Driving Lane
Local Streets		
Low** AADT	5	½ Driving Lane
High** AADT	10	½ Driving Lane

Roadway Classification	Design Frequency (yr)	Allowable Spread
sag	10	½ Driving Lane

* Source: UDOT Roadway Drainage Manual
** Low ADT: <500 vehicle per day, Refer to current UDOT traffic map for latest AADT

3.2.2 Gutter Pans

Gutter pans may be allowed. The City Engineer will review and may approve on a case-by-case basis. It is recommended to use inlets at both sides of the intersection and use storm drain pipes to route storm water into the nearest storm drain network.

3.2.3 Roadside Ditches

Roadside ditches shall be designed to convey 10-year peak flow with maximum water surface elevations not to overtop the bank. The following is the minimum design standards for all roadside ditches:

- Side Slopes: 3H:1V or flatter – to follow UDOT's speed criteria
- Freeboard: Not required
- Minimum Velocity: 3.5 fps (flowing full)
- Maximum Velocity: as determined by erosion protection
- Grade: minimum and maximum grade shall be determined based on minimum and maximum velocity outlined above
- Erosion Protection: vegetative growth, lining and/or riprap is required
- Drainage Easement: required if ditch is not contained with the public ROW

3.3 Open Channel Flow

Manning's equation shall be used to model open channel flow. Table 3-2 lists Manning's coefficient values for various types of streams and channels. Table 3-3 lists Manning's coefficient values for various types of closed conduits.

Table 3-2: Manning's n Values for Streams and Channels

Type of Channel and Description	Manning's n		
	Min	Rec*	Max
EXCAVATED OR DREDGED			
1. Earth, straight and uniform			
a. Clean, recently completed	0.016	0.018	0.020
b. Clean, after weathering	0.018	0.021	0.025
c. Gravel, uniform section, clean	0.022	0.026	0.030
d. With short grass, few weeds	0.022	0.027	0.033

Type of Channel and Description	Manning's n		
	Min	Rec*	Max
2. Earth, winding and sluggish			
a. No vegetation	0.023	0.026	0.030
b. Grass, some weeds	0.025	0.029	0.033
c. Dense weeds or aquatic plans in deep channels	0.030	0.035	0.040
d. Earth bottom and rubble sides	0.025	0.030	0.035
e. Stony bottom and weedy sides	0.025	0.035	0.045
f. Cobble bottom and clean sides	0.030	0.040	0.050
3. Dragline-excavated or dredged			
a. No vegetation	0.025	0.029	0.033
b. Light brush on banks	0.035	0.048	0.060
4. Rock cuts			
a. Smooth and uniform	0.025	0.032	0.040
b. Jagged and irregular	0.035	0.042	0.050
5. Channels not maintained, weeds and brush uncut			
a. Dense weeds, high as flow depth	0.050	0.085	0.120
b. Clean bottom, brush on sides	0.040	0.060	0.080
c. Same, highest stage of flow	0.045	0.078	0.110
d. Dense brush, high stage	0.080	0.110	0.140
NATURAL STREAMS			
1. Minor streams (top width at flood stage < 30 m)			
1.1. Streams on plain			
a. Clean, straight, full stage, no rifts or deep pools	0.025	0.029	0.033
b. Same as above, but more stones/weeds	0.030	0.035	0.040
c. Clean, winding, some pools/shoals	0.033	0.039	0.045
d. Same as above, but some weeds/stones	0.035	0.042	0.050
e. Same as above, lower stages, more ineffective slopes and sections	0.040	0.047	0.055
f. Same as 4, but more stones	0.045	0.052	0.060
g. Sluggish reaches, weedy, deep pools	0.050	0.065	0.080
h. Very weedy reaches, deep pools, or floodways with heavy stand of timber and underbrush	0.075	0.112	0.150
1.2. Mountain streams, no vegetation in channel, banks usually steep, trees and brush along banks submerged at high stages			
a. Bottom: gravels, cobbles and few boulders	0.030	0.040	0.050

Type of Channel and Description	Manning's n		
	Min	Rec*	Max
b. Bottom: cobbles with large boulders	0.040	0.055	0.070
2. Floodplains			
2.1. Pasture, no brush			
a. Short grass	0.025	0.030	0.035
b. High grass	0.030	0.040	0.050
2.2. Cultivated area			
a. No crop	0.020	0.030	0.040
b. Mature row crops	0.025	0.035	0.045
c. Mature field crops	0.030	0.040	0.050
2.3. Brush			
a. Scattered brush, heavy weeds	0.035	0.053	0.070
b. Light brush and trees, in winter	0.035	0.047	0.060
c. Light brush and trees, in summer	0.040	0.060	0.080
d. Medium to dense brush, in winter	0.045	0.077	0.110
e. Medium to dense brush, in summer	0.070	0.115	0.160
2.4. Trees			
a. Dense willows, summer, straight	0.110	0.155	0.200
b. Cleared land with tree stumps, no sprouts	0.030	0.040	0.050
c. Same as above, but with heavy growth of sprouts	0.050	0.065	0.080
d. Heavy stand of timber, a few down trees, little undergrowth, flood stage below branches	0.080	0.100	0.120
e. Same as above, but with flood stage reaching branches	0.100	0.130	0.160
3. Major Streams (top width at flood stage > 30 m)			
a. Regular section with no boulders or brush	0.025	0.042	0.060
b. Irregular and rough section	0.035	0.067	0.100

* Recommended values.

3.3.1 Earthen and Lined Channels

- Use Manning's equation to analyze simple ditches, HEC-RAS shall be used to model complex open channels.
- Lining of channels shall be designed permanent for a 10-year event.
- A minimum freeboard of 1 foot or twice velocity head shall be maintained.
- Side slopes shall not exceed the angle of repose of bank material or be steeper than 1V:2H.

3.3.2 Mixed Use Canals

Park City has two tunnels that bring water for mixed use canals, primarily irrigation: the Spiro Tunnel just east of the Park City golf course and the Judge Tunnel at the south end of the city.

The City has to provide 10 cfs of water under Park Ave. on its way to the new splitter which sends irrigation water through pipes and ultimately feeds into Park Meadows golf course. The State Engineer controls the splitter just north-east of Park Ave. and Kearns Blvd. (Mt. Aire) which seems to provide water to the Park Meadows golf course and to the homes in the surrounding area.

Park Meadows water drains to the Pace Homer ditch, which is piped down Kearns Blvd. and into the retention pond at the new treatment plant on the east side of the City. The water eventually flows into Silver Creek.

Park City Mountain Resort makes snow by pumping water from the golf course ponds. Deer Valley makes snow from two sources; a detention pond upstream on their property and the ponds at the base of the mountain (refer to Figure 3-1 for details).

3.3.3 Pipes

Bentley's StormCAD, or similar urban hydrology modeling package, shall be used to model storm drain networks. Approved pipe materials are reinforced and non-reinforced concrete, HDPE, PVC, and CPP.

Table 3-3: Manning's n Values for Pipes.

Type of Pipe	Manning's n	
	Min[1]	Max[2]
Concrete	0.013	0.015
Corrugated Plastic Pipe (CPP)	0.015	0.024
Smooth Line Pipe (HDPE, PVC, Plastic)	0.011	0.015
Steel Pipe	0.012	0.015

1. Used for new, well maintained and good condition
2. Used for older, poorly maintained

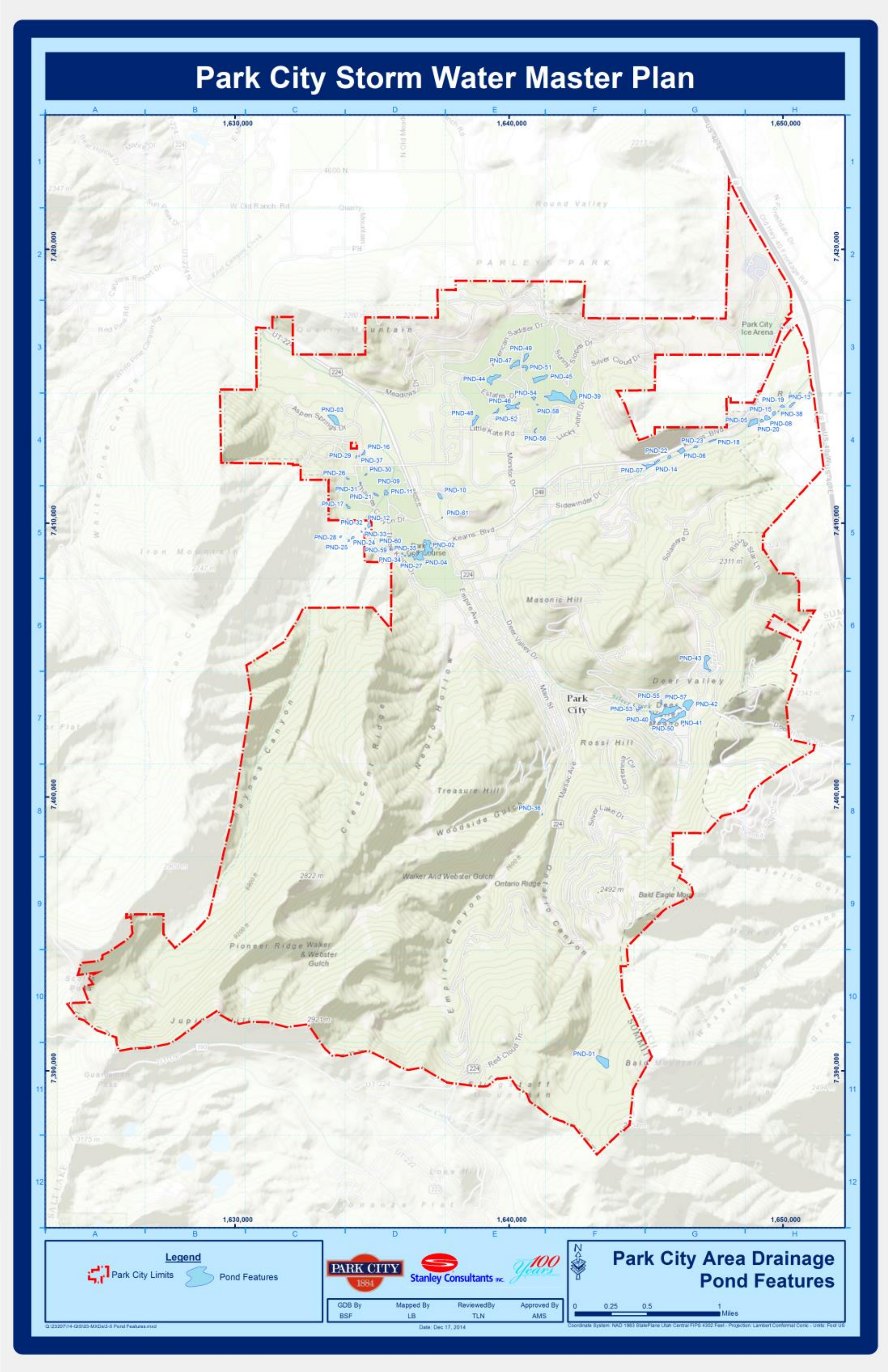

Figure 3-1: Detention Ponds within Park City

Table 3-4: Minimum Storm Drain Pipe Slopes.

Pipe Diameter (in)	Minimum Slope (%)*	
	n = 0.012	n = 0.024
15	0.28	1.11
18	0.22	0.87
24	0.15	0.59
36	0.09	0.34
48	0.06	0.23
60	0.05	0.17
≥ 72	0.03	0.14

* See section 2.8.3 for exceptions

3.4 Culvert and Bridge Design Requirements

- Approved software for culvert analysis is FHWA's HY8 and Bentley's Culvert Master.
- Approved hydrologic model for Bridge stream and scour analysis is HEC-RAS.
- A minimum design life of 50 years shall be acquired for all pipes and culverts.
- Use UDOT Culvert Service Life guidelines (UDOT, 2008).
- Use rectangular and circular culverts only. Elliptical and arch shapes may be allowed depending on site conditions by prior written approval of the City Engineer.
- Allowable headwater: no change to upstream property, 0.5 foot increase over existing FEMA floodplain, or 1 foot increase in unmapped areas.
- Tailwater: use average of critical depth and pipe diameter for the free outfall, or headwater of nearby downstream culverts if greater than channel depth.
- Consider improved inlets for all culverts operating under inlet control.
- Use end treatments for all culverts: headwalls for all culverts > 48" and end sections for smaller sizes.
- Culvert design peak flow is to be calculated on the 50-year design storm as outlined above.
- Minimum culvert size is 24 inches.
- Minimum cover is 2 feet.
- A 1 foot minimum cover for RCP driveway culverts may be accepted with prior written approval from the City Engineer.
- Culvert hydraulic analysis must be done using HY-8 or Culvert Master modeling packages.
- Inlet and outlet improvements must be installed to minimize loses, erosion and facilitate maintenance.

3.5 Storage Facilities

- 100-year event shall be used for detention and 500-year for retention facilities.
- PondPack or similar storage facility modeling package shall be used to model storage facilities.
- A minimum freeboard of 1 foot above the 100-year water surface elevation shall be required.
- A maintenance access shall be provided.
- Maximum (steepest) side slope is 4H:1V.
- Maximum pond water depth of 8 feet. Variations will need to be approved by City Engineer.
- All detention facilities with pond depth more than 4 feet must be fenced.
- Vehicular access must be provided to the bottom of the storage facility. Maximum slope is 8H:1V
- Emergency overflow must be provided. This overflow must be coordinated with the City Engineer.
- Volumetric losses due to evaporation or infiltration shall not be considered while designing the storage facilities.
- Lining of pond bottom must be coordinated with the City Engineer.
- Landscaped according to City standards
- Retention basins may be allowed with prior written approval of the City Engineer.

3.6 Water Velocities

As indicated in Table 3-4, minimum slopes are required to maintain a minimum velocity of 3.5 feet/second at design flow. Water flow velocities shall not exceed 20 feet/second in all sections of all pipes. Water velocities in culvert shall be consistent with velocities in the natural channel in the two sections 100 and 300 feet upstream and downstream.

3.7 Inlets

Storm drain inlets shall be designed to collect storm water from the 10-year storm outlined above. Inlets shall be spaced according to the allowable spread requirements (Table 3-1) and spacing requirements (Table 3-6). Inlets shall be designed to maximize interception and minimize by-pass flow. The following are the general guidelines for inlets:

- Inlet analysis shall be done using HEC-22 to determine grate inlet efficiency and by-pass.
- 30% clogging factor shall be used for all inlets.
- Three flanking inlets shall be used in all sag locations.
- Bicycle safe grates shall be used on all roads allowing bikes.
- Slotted drains are only allowed with prior written approval from the City Engineer.
- No curb opening inlets are allowed.
- Include sumps in inlets – sump depth is 6-8 inches.

3.8 Outlets

This section summarizes the design criteria for detention outlets.

- Minimum discharge orifice area is 4 inches.
- Trash racks are required at all outlets. Acceptable trash rack spacing is 1.5 inches. Continuous cleaning and maintenance of these racks are required. Emergency overflow shall be provided to protect against clogged racks.
- Concrete, plastic or metal end sections must be used when pipes are discharged to earthen channels or detention facilities.
- Riprap, or approved armoring, must be used at outlets to minimize erosion potential.

3.9 Manholes and Clean-Outs

Manholes must be located at changes in pipe size, material, slope, horizontal or vertical alignment. Manhole size is to be determined based on the connecting pipes angles with the minimum diameter as determined by the largest connecting pipe as outlined in Table 3-5.

Table 3-5: Minimum Manhole Size*.

Pipe Diameter (in)	Manhole Diameter (ft)
< 30	4
36-42	5
48-54	6
60-66	7
72-78	8
> 78	Special Provision

* Source: UDOT Roadway Drainage Manual

Depending on the pipe diameter, pipes shall not have horizontal distances between manholes/boxes, more than the allowable spacing indicated in the following table (Table 3-6).

Table 3-6: Maximum Access Hole Spacing*.

Pipe Diameter (in)	Maximum Spacing (ft)
15-24	300
27-36	400
42-54	500
≥ 60	1000

* Source: UDOT Roadway Drainage Manual

3.10 Minimum Cover

Minimum pipe cover will be according to the following table (Table 3-7). Use UDOT's Standard Drawing DG-4 as needed.

Table 3-7: Minimum Pipe Cover*

Pipe Material	Minimum Cover	
	Flexible Pavement	Rigid Pavement
RCP	18"	18"
Plastic	24"	18"
HDPE (Diam > 48")	0.5 * Diameter	0.5 * Diameter

* Source: UDOT Standard Drawing DG-4

3.11 Energy Dissipation and Outlet Protection

Use aprons on all culverts to reduce scour from high headwater depths or high approach velocities. Use HEC-11 and riprap for velocities higher than 4 feet/second and energy dissipaters for velocities higher than 15 feet/second.

3.12 Open Channel Irrigation Infrastructure

Open channel irrigation water must remain uninterrupted at all times during the irrigation season. Should there be a necessity to disrupt existing irrigation infrastructure, temporary facilities shall be required to keep irrigation waters flowing to the designated users promptly.

3.13 Temporary Site Drainage and Liability

Any temporary site development shall not increase the amount of water in any storm water or open channel streams, unless pre-authorized in writing from the City Engineer. In such case, the developer shall be liable for any flooding damage to private or public properties, upstream or downstream, that is a result of the temporary site drainage.

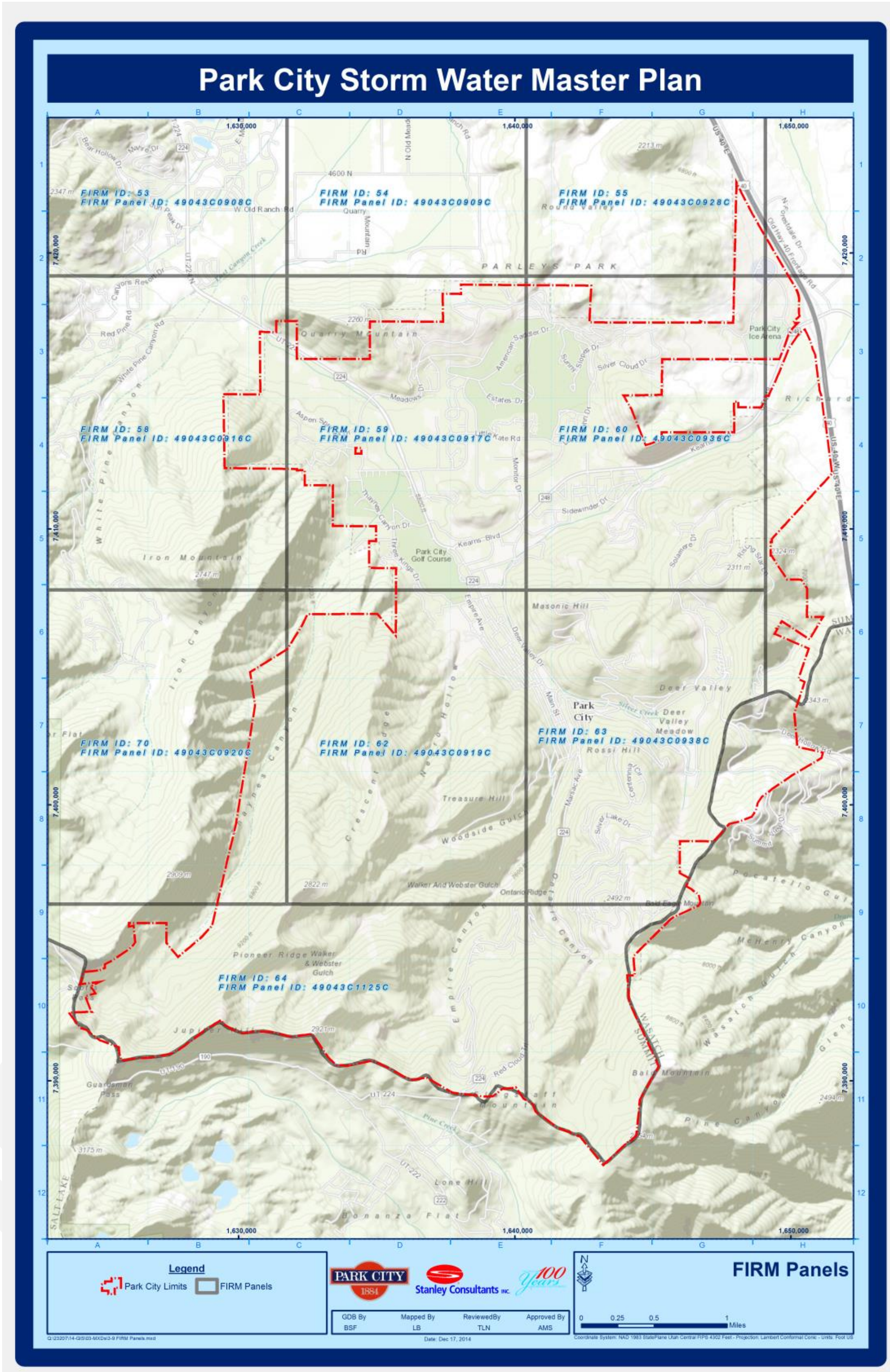

Figure 3-2: Current Firm Panels

Section 4

4. Environmental Protection

Storm water environmental protection is required for: sites greater than one acre disturbed; sites with 5,000 square feet of impervious area; all sites that are commercial or industrial new development; redevelopment sites, regardless of size, with a Standard Industrial Classification (SIC) code that falls under the NPDES Industrial Storm Water Permit program; or a hotspot land use as defined below.

Hotspot is defined as a land use or activity on a site that produces higher concentrations of trace metals, hydrocarbons or other priority pollutants than are normally found in urban storm water runoff. Examples of hotspots include gas stations, vehicle service and maintenance areas, salvage yards, material storage sites, garbage transfer facilities and commercial parking lots with high-intensity use.

4.1 Best Management Practice (BMP)

Storm water best management practices are developed to prevent and/or remove pollutants from the storm drain system. BMP measures are best at the upstream as it is more efficient and less costly than the measures at the basin outlet. BMPs can be temporary or permanent, and structural or non-structural. They can also be classified as source or treatment controls.

Source control BMPs are those to prevent pollutants from the storm drain system. Source control includes public awareness and participation in effective storm water pollution prevention program, enforcement of contaminant and erosion ordinances. Examples of source control BMPs are:

- Surface roughening
- Mulching
- Vehicle tracking control

Treatment control BMPs remove pollutants from the storm drain system. Treatment controls include detention basins, constructed wetlands and oil-water separators. Examples of treatment control BMPs are:

- Check dam
- Riprap

- Inlet protection
- Sediment basin
- Silt fence

The following table and Appendix B include sample applicable BMPs that can be considered for environmental protection in Park City. These BMPs were adapted from various sources including:

- Utah DWQ
- Utah Storm Water Advisory Committee

Additional measures may be needed within the current soil ordinance boundary and other regulated mine tailing sites. Contact Park City Environmental Regulatory Program Manager for details – 435-615-5155.

4.2 Utah Pollution Discharge Elimination System (UPDES)

Before commencing in any construction activity, all new constructions that disturb at least one acre of land must obtain a UPDES Storm Water General Permit for construction activities. The contractor is required to control and eliminate the storm water pollution sources through the Storm Water Pollution Prevention Plan (SWPPP). The permit requires inspection of BMP controls once every 7 calendar days OR every 14 days and within 24 hours of the end of a storm event with depth greater than a half inch.

4.3 Storm Water Pollution Prevention Plan (SWPPP)

For projects that disturb at least one acre of land, the SWPPP must be submitted to the City for approval before a UPDES permit is obtained. Detailed description of items requested to be included in the SWPPP, as well as a SWPPP template, can be obtained from the State of Utah, Division of Water Quality (UDWQ, 2011). It is advised to obtain the most recent version of the SWPPP template from UDWQ website. Current version is located at (www.waterquality.utah.gov/UPDES/Const_SW_swppp_template.doc).

4.4 De-Icing Chemicals

The developer, contractor and owner are required to provide de-icing calculations for both pre- and post-development conditions. The calculations should show an estimate of the outflow average TDS and chloride concentration using the following assumptions. A calculation example is given in Appendix D.

- SNOTEL stations (NRCS, 2011)
- Back of sidewalk to back of sidewalk
- Average daily snowfall (at least 20 years average) for maximum snow day
- De-icing salt application rate: 300 Kg/Lane.Mile
- De-icing salt concentration: 0.92 by weight
- No sand mixing

4.5 Oil Water Separators

Oil water separators are one of many BMPs that can be implemented for storm water treatment. Typically, they can be installed with other storm water BMPs. They shall be used where there is a high potential for oil spills (e.g. commercial parking lots). Oil water separators require monitoring at least once a month and after any significant rain event.

Oil water separators:

- Shall treat 1/3 of 2 year flow.
- Shall remove 60 micron oil droplets with 0.85 specific gravity
- Are not required in residential areas
- Are required for any new development or redevelopment area with parking lot impervious areas (including drivable areas) larger than 5,000 square feet.
- 20 square feet of oil water separator per 10,000 square feet of drainage area.

Section 5

5. Development & Construction Submittal Requirements

5.1 Review Process

As applicable per State of Utah requirements, for sites with one acre or more of disturbed land, the contractor prepares and submits a SWPPP for the City to review. Currently, the state does not require the contractor to prepare a SWPPP for projects that disturb less than one acre. The contractor must file for the Notice of Intent (NOI) and organize a pre-construction meeting with the City. Upon completion and full site stabilization, the contractor files for a Notice of Termination at the State of Utah Division of Water Quality.

5.2 Standardized Submittal

5.2.1 Report Chapter List

The drainage report outline shall be consistent with this drainage manual and have the following chapters as a minimum:

- Executive summary
- Introduction: location, general site information
- Hydrologic calculations
- Hydraulic calculations
- Environmental protection

5.2.2 GIS & CAD Standards

- As-built plans shall be provided in electronic format (CAD or GIS).
- Coordinate system for electronic data shall be Utah State Plane, central zone, US Feet and NAD-83.
- Horizontal datum for electronic data shall be NAD-83.
- Vertical datum for electronic data shall be NAVD-88.

- Grading plans showing existing and proposed 2 feet contour interval are required.
- All electronic files shall be certified by a professional engineer with a current registration at the State of Utah

5.2.3 Appendices

- List of drawings.
- List of pipe segments including lengths, slope, material, calculated design flow, minimum cover, and connecting boxes.
- List of point features with type, size, height, connecting pipes, rim elevation, invert(s) in and invert(s) out.
- List of detention/retention ponds with design volume, free board, inlet and outlet structures.
- Other design nomographs, calculation spreadsheets and model outputs.
- Equations used in spreadsheets, as applicable.

5.3 Drainage Report

A typed, bound and PE-certified drainage report shall be submitted along with the drainage plans. Following is a checklist for the minimum requirements of the drainage report (Appendix C).

- Location and description.
- Major drainage basins.
- Copy of current FIRM.
- Impact from on/off-site basins.
- Impact on on/off-site basins.
- Hydrologic criteria including rainfall, soils, land use, runoff and storage:
    - Design Storm, rainfall distribution, depth, intensity
    - Soil and surface types
    - Land use
    - Time of concentration
    - Modeling approach
    - Soft and hard copies for computer models
- Hydraulic method including capacity, HGL, and routing:
    - Curb & gutter calculations
    - Inlet capacities
    - Storm drain profile including HGL
    - Energy dissipation calculations
    - Culvert profiles and water surface elevations
    - Elevation discharge curves for storage facilities

- Water quality requirements, if applicable.
- Optional provisions and alterations of standard design criteria.
- Waivers and justifications as applicable.
- Drainage pattern, flows and volumes for existing and proposed conditions.
- ROW/easements for storm drain facilities.

5.4 Drainage Plans

A bound and PE-certified drainage plan shall be submitted along with a drainage report. The following is a checklist for the minimum requirements for drainage plan (Appendix D):

- Existing and proposed contours.
- Existing and proposed drainage facilities including sizes and slopes.
- Existing and proposed irrigation facilities.
- Plan and profile of proposed storm drain and irrigation improvements.
- Design storm HGL shown on pipe profile.
- Floodplain boundaries with reference.
- Structure summary table including rim, inverts, bottom elevations, type, grate and referenced standard.
- Conduit summary table including material, diameter, length, slope, structure-out, structure-in, invert-out and invert-in.
- Storage facility grading, details, overflow and outlet structure.
- Drainage ditches cross sections.
- ROW and easement lines.
- Adjacent parcel ownerships.
- Utilities.
- Street cross sections showing flow lines, cross slopes and curb lines.
- Environmental BMPs
- List of utility conflicts.
- Certified record survey shall be prepared by a professional land surveyor with a current registration at the State of Utah.

5.5 Administrative

It is the responsibility of the owner, developer, contractor and any other party responsible for disturbing the land, to immediately stabilize all disturbed areas on abandoned projects.

Section 6

6. References

1. Alaska, 2009: “Alaska Storm Water Guide”, Alaska Department of Environmental Conservation, Anchroage, Alaska, June, 2009.
2. Eckhardt, K., 2005. How to construct recursive digital filters for base flow separation. Hydrological Processes, Volume 19, Issue 2, 507-515, February 2005.
3. NOAA Atlas 14
4. NRCS web site, soil
5. NRCS web site, SNOTEL URL: http://www.wcc.nrcs.usda.gov/nwcc/inventory
6. EPA web site, soil and land use
7. UDOT Drainage Manual
8. USGS, 2012: “Surface Water Data for the Nation”, URL: http://waterdata.usgs.gov/nwis/sw, Last updated: October 6, 2011, Accessed: October 6, 2011,
9. Utah DWQ, State of Utah Division of Water Quality web site, URL: http://www.waterquality.utah.gov/UPDES/updes_f.htm. Accessed November 11, 2011.
10. Utah Storm Water Advisory Committee, URL: http://www.uswac.utah.gov/index.htm , Accessed November 11,2011.

Appendix A

Park City IDF Values

Appendix B

Park City Best Management Practices[1]

[1] Additional measures may be needed within the current soil ordinance boundary and other regulated mine tailing sites. Contact Park City Environmental Regulatory Program Manager for details – 435-615-5155.

Appendix C

Drainage Report and Plans Checklist

Design Criteria:

- ☐ Recurrence interval, oil/water separators: 2 years
- ☐ Recurrence interval, conveyance: 10 years
- ☐ Recurrence interval, sag inlets: 50 years
- ☐ Recurrence interval, bridges & culverts: 50 years (Minor streams)
- ☐ Recurrence interval, bridges & culverts: 100 years (Major streams)
- ☐ Recurrence interval, detention: 100 years
- ☐ Recurrence interval, retention: 500 years
- ☐ Allowable discharge: Pre-development flow
- ☐ Approved models: Rational Method, NSS, HEC-1/HMS, TR55
- ☐ Time of Concentration: Use relevant equation
- ☐ Lag Time: 0.6 x Time of Concentration
- ☐ Storm temporal distribution: Type II
- ☐ Minimum storm drain pipe diameter: 15”
- ☐ Minimum cover for RCP: 18” (see Table 3-7)
- ☐ Minimum cover for non-RCP, Rigid Pvt: 18” (see Table 3-7)
- ☐ Minimum cover for non-RCP, Flexible Pvt: 24” (see Table 3-7)
- ☐ For precipitation data, use upper bound of the 90% confidence interval – NOAA Atlas 14
- ☐ Exceptions may be allowed if approved by City Engineer.
- ☐ HGL – maximum design storm > 1 foot below finished grade at all times
- ☐ Recommended water velocity 3.5 ft/sec
- ☐ Maximum water velocity 10 ft/sec
- ☐ Infrastructure design life 50 years
- ☐ Storm duration application dependent, 12 hour.
- ☐ Detention storm duration maximum detention volume
- ☐ Additional measures may be needed within the current soil ordinance boundary and other regulated mine tailing sites. Contact Park City Environmental Regulatory Program Manager for details – 435-615-5155.

Overall Checklist:

- ☐ Complete set of drainage criteria variances, if needed.
- ☐ Complete set of construction plans (must include landscape development plans).
- ☐ Complete set of specifications (may be designed for several concurrent stages). Where initially submitted and approved, specifications remain relevant for ongoing stages, reference to such specifications clearly noted on plans will satisfy submission requirements.
- ☐ Drainage calculations and approved model input & output. Calculations should show existing and proposed conditions, including pre- and post-development flows. Drainage calculations should include all storm water infrastructure in the site.
- ☐ Current FEMA flood plain map review for the development area.
- ☐ Summary of environmental protection, BMPs and SWPPP (as applicable).
- ☐ Summary table for the 10, 100 and 500 year events showing pre- and post-development flows for the total site as well as each basin.
- ☐ All construction plans to be on 11 x 17 size sheets.
- ☐ PDF copy of drainage report, calculations, all plans and specifications.
- ☐ Soft Copy of all storm water features in GIS or CAD formats.
- ☐ Design drawings must have defined coordinate system. Coordinate system must be a standard coordinate system; i.e. UTM, State Plane. Modified State Plane coordinate systems are acceptable as long as necessary projection parameters are included and a projection file is associated with the drawings.
- ☐ Design plans should at least include:
  - Vicinity Map
  - Site Plan
  - Existing conditions including overall runoff flow patterns, existing basin boundaries, topography, storm water infrastructure, flood plain limits and information, attribute information of each basin and outfalls, property lines and easements.
  - Demolition plan (as applicable).
  - Proposed conditions: including modified runoff flow patterns, proposed basin boundaries, topography, storm water infrastructure, flood plain limits and information, attribute information of each basin and outfalls, environmental protection, property lines and easements.
  - Topography should have at least a 2 foot interval.

Drainage Report Checklist:

- ☐ Typed, Bound (not 3 ring) Report
- ☐ P.E. Certification
- ☐ Location, Name of Surrounding Developments
- ☐ Description of Property, Area, Irrigation Facilities, Major
- ☐ Drainage ways, Easements
- ☐ Major Drainage Basins and Sub-Basins
- ☐ Major Basin Description, Copy of Current FIRM
- ☐ Sub-basin Description, Impact from On- and Off-site Basins
- ☐ Regulations: Optional Provisions and Deviations
- ☐ Development Criteria References/Constraints
- ☐ Hydrologic Criteria: Rainfall, Soils, Runoff and Storage Calculation Methods, Design Storm Recurrence Interval
- ☐ Hydraulic Criteria: Conveyance Facility Capacities, HGL Calculations, Routing Methods
- ☐ Water Quality Requirements, BMPs
- ☐ Waivers from Criteria, Justification for each Waiver
- ☐ Drainage Facility Design - General Concept: Discussion of Drainage Patterns and Impact on Upstream and Downstream Properties
- ☐ Specific Details: Flows, Volumes, Existing and Proposed Facilities; Detention Storage and Outlet Design; Maintenance Access; Structural and Non-Structural BMPs; Appearance and Safety
- ☐ ROW or Easements Provide Adequate Space for Drainage Facilities and Construction Area Requirements
- ☐ Conclusions: Compliance with Standards, Drainage Concept, Effectiveness of Drainage Design, Water Quality Measures Implemented
- ☐ References
- ☐ Appendices: hydrologic and hydraulic calculations, model input/output

Drainage Plans Checklist:

- ☐ Overall Drainage Plan: Delineation of Entire Development and Off-site Basins, Delineation of all Major Basins, Identification of major storm drainage facilities, General Drainage Paths with Flow Arrows

- ☐ Detailed Drainage Plan:

  - Existing (dashed or screened) Contours,
  - Proposed (solid) Contours,
  - Spot Elevations of Critical Points,
  - All Existing and Proposed Drainage Facilities (e.g., Detention Facilities, Storm Sewers, Swales, Riprap, Outlet Structures, Irrigation Ditches, Culverts, Cross Pans),
  - Existing and Proposed Pipe Sizes,
  - Floodplain and Floodway Boundaries and Information Source,
  - Delineation of All Major Basins and Sub-basins,
  - Key Off-site features,
  - Runoff Summary Table,
  - Detention Basin Summary Table,
  - Cross Sections of Drainage Ditches,
  - Finished Floor Elevations,
  - Property and Right-of-Way Lines,
  - Existing and Proposed Easements with Purposes Noted, Tracts, Structures, Fences,
  - Wetlands, Waters of the State and Other Land Features,
  - Adjacent Developments or Ownerships,
  - Street Cross Sections Indicating ROW Width, Flow-line to Flow-line Width, Cross Slope, Sidewalk, Curb Type, Street Slope, Flow Direction and Cross Pan,
  - Proposed Detention Basin Grading and Detention Basin outlet Schematics,
  - Overflow, Directions and Amounts, Emergency Spillway,
  - Water Quality Enhancement BMPs Schematic