

# Storm Drain Master Plan

***DRAFT***

September 2015

Prepared by:

Bowen Collins
& Associates, Inc.
CONSULTING ENGINEERS

# STORM DRAIN MASTER PLAN

## September 2015

**Project No. 235-14-01**

# DRAFT

**Prepared for:**

City of Ivins, Utah

**Prepared by:**

Bowen Collins & Associates, Inc.
CONSULTING ENGINEERS

# TABLE OF CONTENTS

**Page No.**

**CHAPTER 1 – INTRODUCTION ..... 1-1**
Introduction ..... 1-1
Scope of Services ..... 1-1
Authorization ..... 1-2
Project Staff ..... 1-2
Ivins City Staff ..... 1-2
Ivins City Council ..... 1-2

**CHAPTER 2 – EXISTING FACILITIES ..... 2-1**
Introduction ..... 2-1
Service Area ..... 2-1
Storm Drainage Pipes ..... 2-1
Flood Streets ..... 2-1
Open Channels ..... 2-2
Detention Basins ..... 2-2

**CHAPTER 3 – HYDROLOGIC ANALYSIS ..... 3-1**
Subcatchment Delineation ..... 3-1
Hydrologic Model Parameters ..... 3-1
Hydrology Method ..... 3-1
Loss Method ..... 3-2
Composite Curve Number ..... 3-2
Directly-Connected Impervious Area ..... 3-2
Slope ..... 3-3
Design Storm Parameters ..... 3-3
Model Calibration ..... 3-4
Subcatchment Width ..... 3-5
Hydrologic Modeling Assumptions ..... 3-5
Existing Inlet Capacity Issues ..... 3-6

**CHAPTER 4 – HYDRAULIC MODELING ..... 4-1**
Geometric Model Development ..... 4-1
Modeled Conveyance ..... 4-1
Detention Basins ..... 4-1
Profiles ..... 4-2

**CHAPTER 5 – SYSTEM EVALUATION ..... 5-1**
Evaluation Criteria and Level of Service ..... 5-1
Storm Drain Pipelines ..... 5-1
Flood Streets ..... 5-1
Open Channels ..... 5-1
Culverts ..... 5-1

## TABLE OF CONTENTS
## (continued)

**Page No.**

Detention Basins ..... 5-1
Existing Conveyance System Analysis ..... 5-1
Future Conveyance System Analysis ..... 5-2

**CHAPTER 6 – RECOMMENDED SYSTEM IMPROVEMENTS ..... 6-1**
Recommended Pipeline Improvements ..... 6-1
Detention Basin Improvements ..... 6-5
Culvert Improvements ..... 6-6

## LIST OF APPENDICES

**APPENDIX A – HYDROLOGIC DATA**
**APPENDIX B – LARGE STORM EVENTS**
**APPENDIX C – COST ESTIMATES**

# TABLE OF CONTENTS
**(continued)**

## LIST OF TABLES


| No. | Title | Page No. |
|---|---|---|
| 2-1 | Ivins Storm Drain Pipe Lengths | 2-1 |
| 3-1 | SCS Curve Number | 3-2 |
| 3-2 | Average Imperviousness Based on Land Use | 3-3 |
| 3-3 | Mountain Watershed Model Calibration | 3-5 |
| 6-1 | Storm Drain Trunkline Improvements | 6-2 |
| 6-2 | Required Capacity at Detention Basins | 6-5 |
| 6-3 | Required Capacity at Culverts | 6-6 |

# TABLE OF CONTENTS
## (continued)

## LIST OF FIGURES


| No. | Title | On or Following Page No. |
|---|---|---|
| 2-1 | Existing Storm Drain System | 2-1 |
| 3-1 | Existing Land Use | 3-3 |
| 3-2 | Buildout Land Use | 3-3 |
| 3-3 | Hydrologic Model | 3-3 |
| 4-1 | Hydraulic Model | 4-1 |
| 5-1 | Existing Deficiencies | 5-1 |
| 6-1 | Proposed Projects | 6-1 |

# CHAPTER 1
# INTRODUCTION

## INTRODUCTION

The City of Ivins retained Bowen Collins & Associates (BC&A) to prepare this master plan for the City's storm drain system. The City determined that a new storm drain master plan was needed before a new Capital Facilities Plan could be completed.

The primary purpose of this Storm Drain Master Plan is to provide recommended improvements to resolve existing deficiencies and plan for future growth in the City's storm drain system based on the adopted General Plan.

This document is a working document. Some of the recommended improvements identified in this report are based on the assumption that development and/or potential annexation will occur in a certain manner. If future growth or development patterns change significantly from those assumed and documented in this report, the recommendations may need to be revised. The status of development should be reviewed at least every five years. This report and the associated recommendations should also be updated every five years.

## SCOPE OF SERVICES

The general scope of this project involved a thorough analysis of City's storm drain system and its ability to meet the present and future storm drain needs of its residents. As part of this project, BC&A completed the following tasks:

**Task 1:** Review data provided by Ivins City and set up a hydraulic model using InfoSWMM. Collect and review state and federal guidelines.

**Task 2:** Establish appropriate rainfall depths for the hydrologic model for storms with a 10% and 1% probability of occurring in any given year (10-yr and 100-yr Storm). The Farmer Fletcher Storm distribution was used for master planning purposes to simulate a cloudburst type storm. Develop a hydrologic computer model of the study area for land use conditions, using City zoning and land use information. Develop subcatchment boundaries for the use of this model. Develop parameters for these subcatchments. Calibrate model to runoffs reasonable to the area. Insert detention basins with the associated stage storage curves.

**Task 3:** Develop and review existing deficiencies with City personnel and develop conceptual solutions.

**Task 4:** Modify Existing Conditions Hydraulic model (Task 1) for future growth based on the City's zoning and land use information. Propose capital improvements that resolve existing deficiencies and allow for planned future growth, including cost estimates and a phasing plan for implementing these improvements.

**Task 5:** Develop an Impact Fee Facility Plan (IFFP) based on the capital improvements identified as part of Task 4 or this report.

**Task 6:** Prepare a draft master plan and IFFP report to be reviewed with city personnel. Incorporate comments and finalize master plan report.

This report is prepared as part of Task 6.

## AUTHORIZATION

Ivins contracted the services of BC&A to prepare this Storm Drain System Capital Facilities Plan in December of 2014.

## PROJECT STAFF

The project work was performed by the BC&A team members listed below. Team members' roles on the project are also listed. The project was completed in BC&A's St. George, Utah office. Questions may be addressed to Todd Olsen, Project Manager at (435) 656-3299.

| | |
|---|---|
| Craig Bagley | Principal-In-Charge |
| Todd Olsen | Project Manager |
| Nathan Wright | Project Engineer |
| Mike Hilbert | Word Processing |

## IVINS CITY STAFF

City staff also worked closely with BC&A personnel in collecting data associated with this masterplan. The following City personnel were influential in the completion of this master plan.

| | |
|---|---|
| Dale Coulam | City Manager |
| Wally Ritchie | Director of Finance |
| Chuck Gillette | Public Works Director/City Engineer |
| Tom Jorgensen, | Assistant Public Works Director of Administration |
| Shiloh Pentz | Assistant Public Works Director of Operations |

## IVINS CITY COUNCIL

The following elected officials participated in the review and approval of this masterplan:

| | |
|---|---|
| Chris Hart | Mayor |
| Ron Densley | Councilperson |
| George Elwell, Jr. | Councilperson |
| Cheyne McDonald | Councilperson |
| Lesley Mendenhall | Councilperson |
| Steven Roberts | Councilperson |

# CHAPTER 2
# EXISTING FACILITIES

## INTRODUCTION

As part of this Master Plan, BC&A has assembled an inventory of existing infrastructure within the storm drain system. The purpose of this chapter is to present a summary of the inventory of Ivins City's existing storm drain system that can be used as a reference for future studies.

## SERVICE AREA

The City of Ivins, which was first incorporated as a town in 1935, is located about 8 miles Northwest of St. George City in Washington County, Utah. The topography of the majority of the City slopes from North to South towards the Santa Clara River. There are three main washes, Coyote Wash, Kayenta Wash, and Tuacahn Wash, which convey stormwater through the city to the Santa Clara River. Figure 2-1 shows the approximate planning extent of Ivins along with the City's storm drain collection system components.

## STORM DRAINAGE PIPES

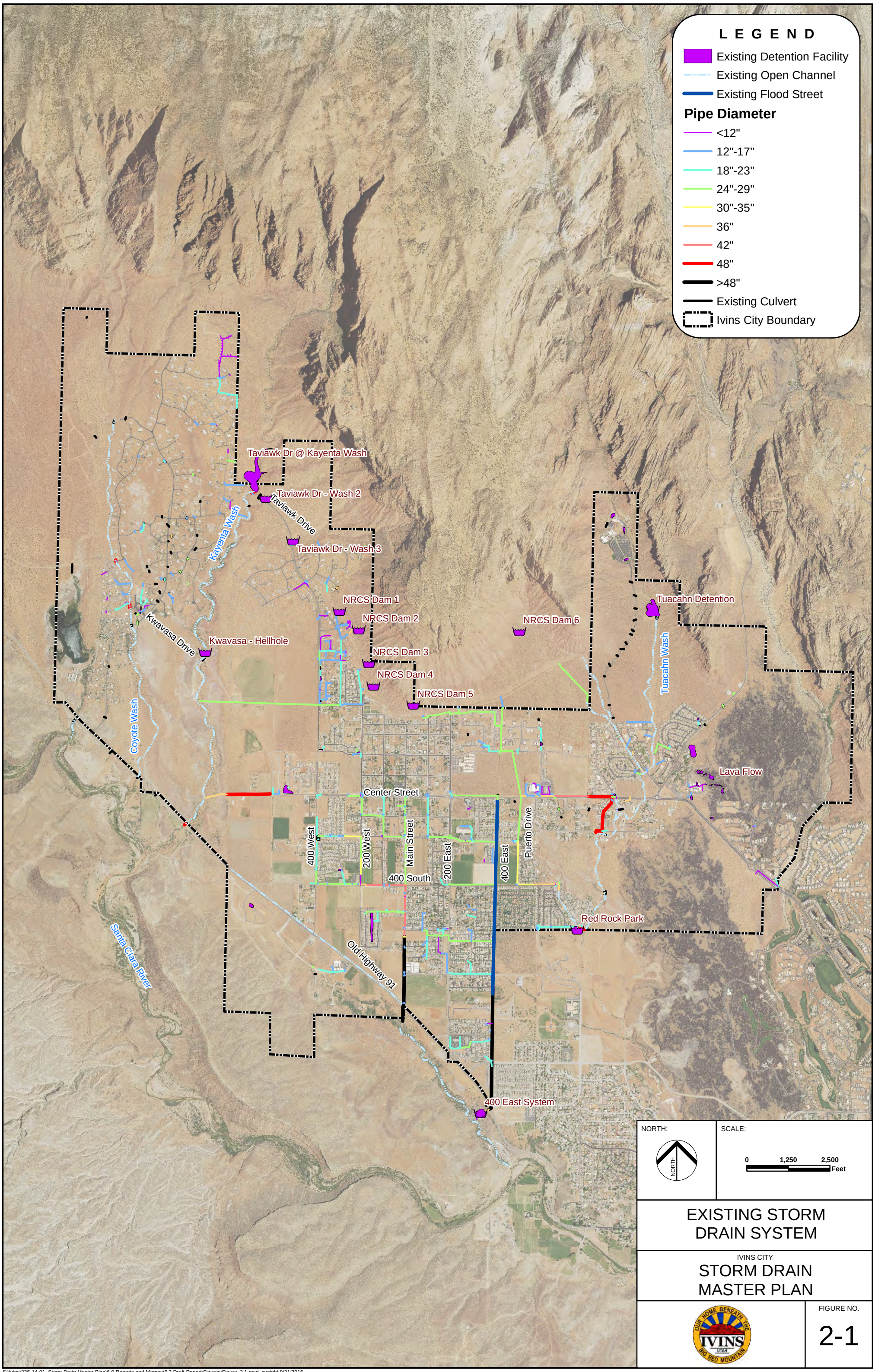
There are just over 126,000 feet (23 miles) of storm drain pipe and over 850 manholes in the Ivins City Storm Drain System that are cataloged in the GIS database. Table 2-1 contains a summary of the storm drain pipes for the Ivins City collection system.

**Table 2-1**
**Ivins Storm Drain Pipe Lengths**

| Diameter (in) | Length (ft) | Length (mi) |
|---|---|---|
| <12" | 14,705 | 2.8 |
| 12"-17" | 24,457 | 4.6 |
| 18"-23" | 24,577 | 4.7 |
| 24"-29" | 37,985 | 7.2 |
| 30"-35" | 3,220 | 0.6 |
| 36"-41" | 6,186 | 1.2 |
| 42"-47" | 3,738 | 0.7 |
| 48" | 4,630 | 0.9 |
| >48" | 6,794 | 1.3 |
| **Total** | 126,292 | 23.9 |

### Flood Streets

A 5,800 linear foot section of the 400 East roadway, between Center Street and 900 South, has been designated as a flood street in the storm drain system. The flood street consists of the v-




S:\Ivins\235-14-01_Storm Drain Master Plan\6.0 Reports and Memos\6.2 Draft Report\Figures\Figure_2.1.mxd nwright 9/21/2015

shaped roadway that slopes to a waterway in the middle of the street. The waterway conveys flows to a series of inlets which collect stormwater into a network of small pipes. Flows exceeding the pipe capacity are conveyed in the roadway to the end of the street where a network of inlets allow flows to enter the trunkline system.

### Open Channels

There are over 54,000 feet (10 miles) of open channels which were modeled as part of the existing storm drain system. These open channels included natural and manmade/maintained channels. Open channels play a major role in conveying storm water from mountain watersheds to the Santa Clara River. They also act as an outlet for several storm drain pipes.

## DETENTION BASINS

There are over 30 detention facilities in the existing storm drain system. The majority of these detention facilities are local detention basins and were not accounted for as part of this study. The primary purpose of the detention facilities is to attenuate peak storm water discharges. Many of the detention facilities serve the dual purpose of a recreational park. Figure 2-1 shows all of the detention facilities in the City's system. Those labeled were included in the InfoSWMM model.

# CHAPTER 3
# HYDROLOGIC ANALYSIS

Ivins City was divided into three hydrologic study areas for the purposes of this master plan update, a Mountain Watershed Study Area, a Central Study Area, and a Valley Study Area. A hydrologic computer model was developed in InfoSWMM, Suite 12.0, for the purpose of estimating storm water runoff volume and peak discharges generated by a design cloudburst event. InfoSWMM uses an Environmental Protection Agency Storm Water Management Model (EPA-SWMM) engine to perform computations. As with EPA-SWMM, InfoSWMM has the capability to model the hydrologic and hydraulic components of storm water runoff, and was used to model both in this study. See Chapter 4 for a description of the hydraulic modeling.

The model development process includes delineating drainage basins, estimating hydrologic parameters, developing a design storm and calibrating the model. Each one of these steps is described below.

## SUBCATCHMENT DELINEATION

The first step in developing a computer hydrologic model is to delineate subcatchments. BC&A worked with Ivins city personnel to delineate subcatchment boundaries. Approximately 63 subcatchments were included in the model and boundaries associated with the hydrologic model are shown in Figure A-1. Discharge points for these subcatchments can be seen in Figure A-2. Table A-1 shows the runoff produced for each subcatchment.

## HYDROLOGIC MODEL PARAMETERS

The following hydrologic model parameters were used to develop the InfoSWMM computer model.

### Hydrology Method

In the InfoSWMM software there are multiple options for Hydrology Method. The EPA-SWMM non-linear reservoir method was used in this study. The EPA-SWMM non-linear reservoir method is the same method EPA SWMM uses. This method requires “subcatchment width” and slope as input parameters. The subcatchment width was calculated using one of InfoSWMM’s built in functions:

$$W = k * \text{Area}^{0.5}$$

Where:

W – Subcatchment Width

*k* – Coefficient (typically range between 0.1 - 0.5)

Area – Area (acres)

Several values of *k* were used throughout the City. See "Model Calibration" for additional information.

**Loss Method**

The SCS Curve Number method was used in InfoSWMM to calculate infiltration losses (see Natural Resources Conservation Service (NRCS) TR-55 publication for additional information). This method requires the input of a composite Curve Number and the percent impervious for each subcatchment.

**Composite Curve Number.** Curve Numbers were estimated for each subcatchment based on soil type and vegetative ground cover. The hydrologic soil type was obtained from the NRCS Soil Survey Geographic (SSURGO) dataset. In order to be more consistent, the NRCS recently updated the raw data for Tobler Fine Sandy Loam ($T_c$) from being a hydrologic soil type B to a type A. Based on past experience in the area the soil class was left as B soil type to better simulate historic runoff. Future masterplans developed in Ivins City will need to continue to classify the $T_c$ soil type as Class B soil to match this masterplan and historic runoff. Table 3-1 shows the Curve Numbers used in this study, based on soil type and assumed vegetative ground cover for developed areas. See Figure A-3 for the location of the various soil types. Ivins has experienced multiple extreme storms where the storm distribution contained multiple peaks in a short period. (Appendix B contains details regarding the recent extreme storms.) For this reason multiple Antecedent Moisture Content (AMC) conditions were considered. See Figure A-4 for boundaries where different AMC values were used.

**Table 3-1**
**SCS Curve Number**

| Soil Type | Curve Number (AMC II)* | Curve Number (AMC III)** |
|---|---|---|
| A | 63 | 80 |
| B | 77 | 89 |
| C | 85 | 94 |
| D | 88 | 95 |

*From Table 2-2 in TR-55 "Desert Shrub (Poor Hydrologic Condition)"[1]

** AMC III curve number were used in the mountain area[2]

**Directly-Connected Impervious Area.** The amount of directly-connected impervious area for existing conditions was estimated using the 2014 National Agriculture Imagery Program (NAIP). Each Land Use type was analyzed and the estimated impervious area was recorded. The amount of directly-connected impervious area was also estimated for full build-out conditions based on land use from the General Plan. For areas that are currently undeveloped, the General Plan was

[1] United States Department of Agriculture. (1988). *Urban Hydrology for Small Watersheds: TR-55.* Washington, D.C.: USDA.

[2] United States Department of Agriculture. (2004). Part 630 Hydrology National Engineering Handbook. *Chapter 10: Estimation of Direct Runoff from Storm Rainfall.* Washington, D.C.: USDA.

used in conjunction with Table 3-2 to estimate the impervious area. See Figures 3-1 and 3-2 for existing and buildout land use projections.

**Table 3-2**
**Average Imperviousness Based on Land Use**

| General Plan Land Use Type | Directly Connected Imperviousness (Percent) |
|---|---|
| Open Space | 0 |
| Low Impact Development | 7-15 |
| Low Density Residential (LDR) | 18-25 |
| Tuacahn Resort | 20 |
| Park | 25 |
| Medium Density Residential (MDR) | 30 |
| School | 40 |
| High Density Residential (HDR) | 40-55 |
| RMU - Village | 55 |
| Commercial/Light Manufacturing | 70 |
| Church | 75 |
| RMU-Town Center | 85 |
| Commercial | 85 |
| Commercial Neighborhood | 85 |
| Commercial Resort | 85 |

* Note areas of Low Impact Development (LID) with a directly connected impervious area of 7 percent incorporated the use of cisterns, reducing the direct runoff to the system.

### Slope

The average slope for each subcatchment was calculated using a Digital Elevation Model (DEM). Ivins City provided a 3-foot resolution DEM which extended to city limits. A 10-foot resolution DEM was used for areas outside of city limits. The Arc View GIS system was used to mosaic the two DEMs together. The average slope for each subcatchment was calculated using tools within InfoSWMM. Average slopes ranged throughout the city from 2.9% to 76%.

## DESIGN STORM PARAMETERS

Multiple design storm boundaries were used to best represent conditions experienced by the city during storm events. These design storm boundaries are shown on Figure 3-3. The parameters for the design storms are described below:

- Storm Duration: 3 Hours
- Storm Distribution: Modified Farmer and Fletcher
- Recurrence Interval:
    - City Drainage: 10-Year Storm

**L E G E N D**

Model Subcatchments

**Percent Impervious**

- 0
- 7
- 15
- 18
- 20
- 25
- 30
- 40
- 55
- 70
- 75
- 85

Ivins City Boundary

Kayenta Wash

Taviawk Drive

Kwavasa Drive

Coyote Wash

Tuacahn Wash

Lava Flow

Center Street

400 West

200 West

Main Street

200 East

400 East

Puerto Drive

400 South

Santa Clara River

Old Highway 91

NORTH:

NORTH

SCALE:

0 1,250 2,500 Feet

# EXISTING LAND USE

IVINS CITY

## STORM DRAIN MASTER PLAN

FIGURE NO.

3-1

S:\Ivins\235-14-01_Storm Drain Master Plan\6.0 Reports and Memos\6.2 Draft Report\Figures\Figure_3.1.mxd nwright 9/21/2015

L E G E N D

Model Subcatchments

**Percent Impervious**

0
7
15
18
20
25
30
40
55
70
75
85

Ivins City Boundary

Taviawk Drive
Kwavasa Drive
Lava Flow
Center Street
400 West
200 West
Main Street
200 East
400 East
Puerto Drive
400 South
Old Highway 91

NORTH:

NORTH

SCALE:

0 1,250 2,500 Feet

# FUTURE LAND USE

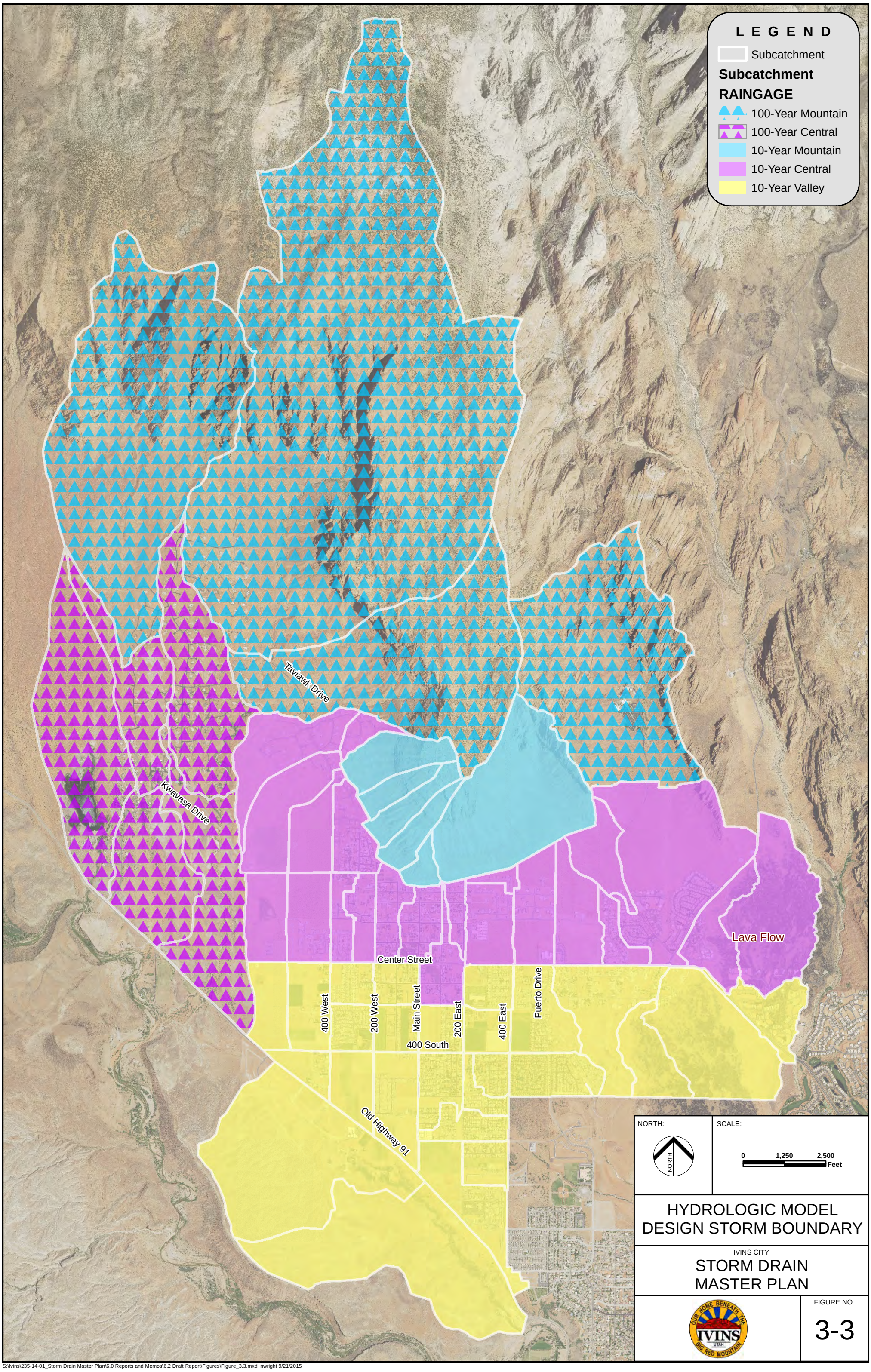
IVINS CITY

# STORM DRAIN MASTER PLAN

FIGURE NO.

3-2

S:\Ivins\235-14-01_Storm Drain Master Plan\6.0 Reports and Memos\6.2 Draft Report\Figures\Figure_3.2.mxd nwright 9/22/2015




# HYDROLOGIC MODEL DESIGN STORM BOUNDARY

IVINS CITY

## STORM DRAIN MASTER PLAN

FIGURE NO.

3-3

S:\Ivins\235-14-01_Storm Drain Master Plan\6.0 Reports and Memos\6.2 Draft Report\Figures\Figure_3.3.mxd nwright 9/21/2015

- Mountain Drainage: 100-Year Storm

- Storm Depth (Upper Bound from NOAA Atlas 14)[3]:

| | | |
|---|---|---|
| Mountain Area | 100-Year | 2.41 inches |
| Central Area | 100-Year | 2.19 inches |
| Central Area | 10-Year | 1.30 inches |
| Valley Area | 10-Year | 1.25 inches |

General engineering practice is to use NOAA Atlas 14 average depths based on the design storm. Ivins City has experienced multiple extreme storms in recent year that have exceeded these average depths. Based on conversations with City personnel it was decided to use the NOAA Atlas 14 upper bound depth, instead of the NOAA Atlas 14 average depth. This was done to yield results similar to those seen by City personnel in recent years. See Tables A-2 through A-4 for NOAA Atlas 14 depths.

## Model Calibration

The final step in the hydrologic modeling process is model calibration. In general, calibration of a hydrologic model within an urban area refers to the process of adjusting parameters to achieve results consistent with available reference information in nearby areas rather than adjusting for actual measured discharge observations in the study area. Based on engineering judgement and experience on studies performed on neighboring cities, a typical quarter acre development will produce 0.25 – 0.45 cfs per acre of runoff based on average NOAA Atlas 14 depths. This range was used as a basis for calibrating the developed area of the city.

As mentioned previously, in the past 5 years, Ivins City has experienced multiple extreme storms larger than the 100-year event. The City measured depths in multiple detention facilities that collect runoff from mountain watersheds. Storm distributions for these extreme storms were also used in calibrating mountain areas. Appendix B gives details regarding the recent large storms seen in Ivins City. Table 3-3 gives a comparison of depth in the different detention facilities used to calibrate the model.

[3] NOAA's National Weather Service. (2015). *Hydrometeorological Design Studies Center Precipitation Frequency Data Server (PFDS)*.

**Table 3-3**
**Mountain Watershed Model Calibration**

| Detention Facility/Dam | Bottom Elevation of Facility | Measured Water Surface Elevation | Modeled Water Surface Elevation | Water Surface Elevation Difference |
|---|---|---|---|---|
| NRCS Dam 1 | 3274.5 | 3279.5 | 3279.8 | -0.3 |
| NRCS Dam 2 | 3254.1 | 3260.2 | 3260.3 | -0.1 |
| NRCS Dam 3 | 3231.0 | 3232.8 | 3232.9 | -0.1 |
| NRCS Dam 4 | 3200.6 | 3205.4 | 3204.7 | 0.7 |
| NRCS Dam 5 | 3170.4 | 3171.8 | 3171.6 | 0.3 |
| NRCS Dam 6 West | 3181.2 | 3185.6 | 3184.1 | 1.5 |
| NRCS Dam 6 Central | 3181.2 | 3183.7 | 3184.8 | -1.1 |
| NRCS Dam 6 East | 3181.2 | 3184.8 | 3185.2 | -0.4 |
| Taviawk Dr. | 3208.5 | 3224.5 | 3224.7 | -0.2 |

### Subcatchment Width

The subcatchment width is the theoretical width of the overland flow. For the purpose of this report the subcatchment width was calculated using the following methods to get reasonable unit discharges.

- Width = k*sqrt (Area)

Subcatchment width was adjusted as needed to get runoff values as described above. Values of k varied from 0.1 to 0.4, depending the size and slope of the subcatchment.

## HYDROLOGIC MODELING ASSUMPTIONS

The following assumptions were also made in completing the hydrologic analyses of the study area:

1. Rainfall return frequency is equal to associated runoff return frequency.
2. Design storm rainfall has a uniform spatial distribution over the watershed.
3. The hydrologic computer model adequately simulates watershed response to precipitation.
4. Hydrologic parameters for non-developable areas were assumed to have normal mid-summer vegetation cover, free from recent fire damage.
5. Runoff produced by the storm event can collect in each detention basin and eventually flow into the City Facilities.
6. No areal reduction factors were included.

## Existing Inlet Capacity Issues

The collective assumption was made that there are enough existing storm water inlets in each subcatchment to collect runoff from a 10-year design storm event. In areas where ponding or flooding occurs, the inlet capacity should be evaluated and additional inlets should be added if necessary.

# CHAPTER 4
# HYDRAULIC MODELING

A hydraulic computer model of the study area was developed in InfoSWMM for the purpose of routing storm water runoff and estimating the capacity of the existing storm drain facilities. InfoSWMM uses an EPA-SWMM engine to perform hydraulic computations. As with EPA-SWMM, InfoSWMM can be used to model the hydrologic and hydraulic components of the study. See Chapter 3 for a description of the hydrologic modeling.

## GEOMETRIC MODEL DEVELOPMENT

There are two major types of data required to create a hydraulic model of a storm drain system: geometric data and flow data. Geometric data consists of all information in the model needed to represent the physical characteristics of the system, including pipelines, open channels and detention basins. Flow data is part of the hydrologic analysis reported in Chapter 3.

### Modeled Conveyance

It was not economically feasible to model all of the storm drain pipes in Ivins City's system. As smaller pipes are added to the model, the more refined the analysis becomes, but this requires additional time, effort, and expense. Hence, it is important to consider the required accuracy and available budget when selecting the storm drain pipes to model. This analysis has correspondingly been limited to the major trunk lines (18" or larger) in the City servicing multiple developments. Project level improvements serving single developments have not been included at this time.

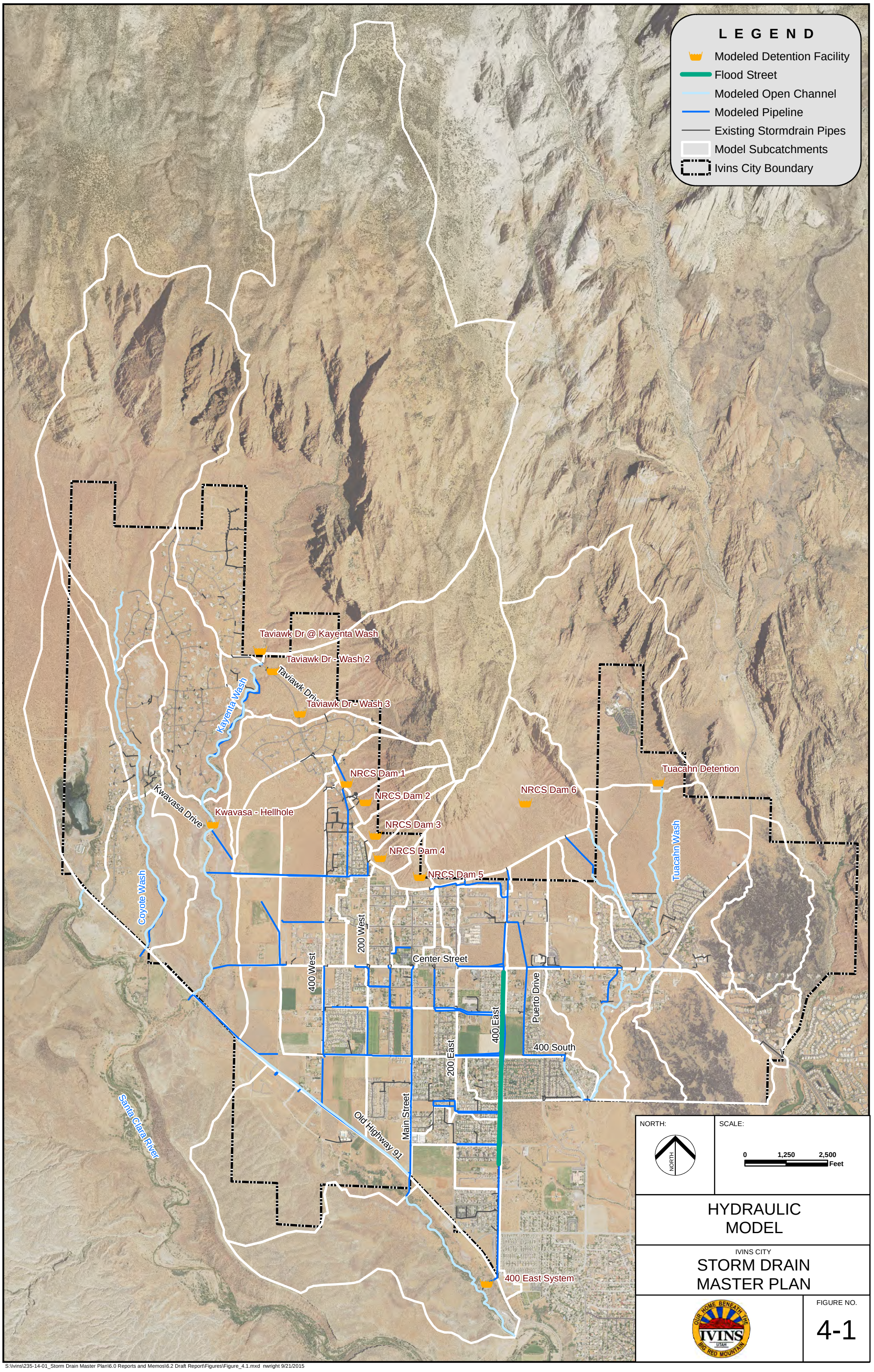
A framework for the model was developed using GIS files provided by Ivins City personnel. These files contained information regarding type, lengths, diameter, materials, and inverts for pipes. Rim elevation and invert elevation were also contained in a GIS file for manholes. This data was imported into the InfoSWMM model.

It should be noted that all pipes were assumed to have a manning's roughness of 0.013 which is consistent with industry standard for concrete pipe. Open Channels were assumed to have manning's roughness of 0.035. Minor losses associated with each manhole were assumed to be 0.3.

### Detention Basins

Stage-storage curves were provided by City personnel for the detention basins and were entered into the model. Orifice information, including size, location, or lack thereof, was provided by the City, and was included in the existing conditions model. Future detention basins were modeled with a synthetic stage storage curve and an orifice to control the release rate. Figure 4-1 presents the modeled existing detention basins.

Detention facilities are either local or regional. For the most part Ivins City detains flows using regional detention facilities. In conversations with Ivins City personnel, it was determined that due to the high impervious areas associated with commercial and industrial developments, local detention of 0.2 cfs per acre will be required for these sites.




S:\Ivins\235-14-01_Storm Drain Master Plan\6.0 Reports and Memos\6.2 Draft Report\Figures\Figure_4.1.mxd nwright 9/21/2015

## Profiles

Profiles for each existing trunkline were examined for unusual data (i.e. adverse slopes, diameter contractions, etc.) and any areas of concern were field verified by City personnel. Updated data was provided by City personnel and entered into the model.

# CHAPTER 5
# SYSTEM EVALUATION

With the development and calibration of a hydraulic storm drain model, it is possible to simulate storm drain system operating conditions for both existing and future conditions. The purpose of this chapter is to document the hydraulic performance evaluation of the collection system and identify potential hydraulic deficiencies.

## EVALUATION CRITERIA AND LEVEL OF SERVICE

To define deficiencies in the system, the desired level of service for each of the storm drain components needs to be defined.

### Storm Drain Pipelines

Storm drain pipelines do not surcharge into the street during the 10-year storm event. It is important to note that roadways become the major storm water conveyance facility during storms that are larger than the 10-year design event.

### Flood Streets

Flood Streets are designed to convey the 1-year storm in the low flow pipe network underneath the roadway. In the 10-year event the flood streets are designed to fill such that a minimum of 1 lane or 10.5 feet in either direction is not submerged.

### Open Channels

Open channels should be designed to safely convey the 100-year design storm event.

### Culverts

Culverts should be designed to safely convey the 100-year design storm event.

### Detention Basins

Detention facilities should be designed to have capacity for the 100-year design storm. Since pipes are designed for the 10-year design storm it is recommended that all detention facilities have a structure that allows flows from the streets to enter the detention facility. It is also recommended that all detention facilities have an emergency overflow that directs water away from private property in an event larger than the 100-year design storm.

## EXISTING CONVEYANCE SYSTEM ANALYSIS

Figure 5-1 shows the deficiencies in the storm drain system under existing development conditions. As can be seen from the Figure, culverts, detention basins, and trunklines were found to be deficient.

**LEGEND**

- Modeled Manhole
- Flooded Manholes
- Flooded Detention
- Modeled Detention
- Flooding Potential
- Existing Pipe
- Modeled Orifice
- Subcatchment

Taviawk Dr @ Kayenta Wash
Taviawk Dr - Wash 2
Taviawk Drive
Taviawk Dr - Wash 3
Kayenta Wash
NRCS Dam 1
NRCS Dam 2
NRCS Dam 3
NRCS Dam 4
NRCS Dam 5
NRCS Dam 6
Tuacahn Detention
Tuacahn Wash
Kwavasa Drive
Kwavasa - Hellhole
Coyote Wash
Center Street
400 West
200 West
Main Street
200 East
400 East
Puerto Drive
400 South
Red Rock Park
Santa Clara River
Old Highway 91
400 East System

NORTH:

SCALE: 0 1,250 2,500 Feet

# EXISTING DEFICIENCIES

IVINS CITY

# STORM DRAIN MASTER PLAN

FIGURE NO. 5-1

S:\Ivins\235-14-01_Storm Drain Master Plan\6.0 Reports and Memos\6.2 Draft Report\Figures\Figure_5.1.mxd nwright 9/21/2015

## FUTURE CONVEYANCE SYSTEM ANALYSIS

A few of the existing storm drain collection trunklines in Ivins are undersized for ultimate development conditions. Additional trunklines will need to be constructed for future development. Also, there are several detention basins that need to be constructed or modified to help alleviate flood and conveyance pressure on the existing storm drain system. Chapter 6 discusses conceptual improvements that will be needed to fix existing deficiencies and allow for planned future growth.

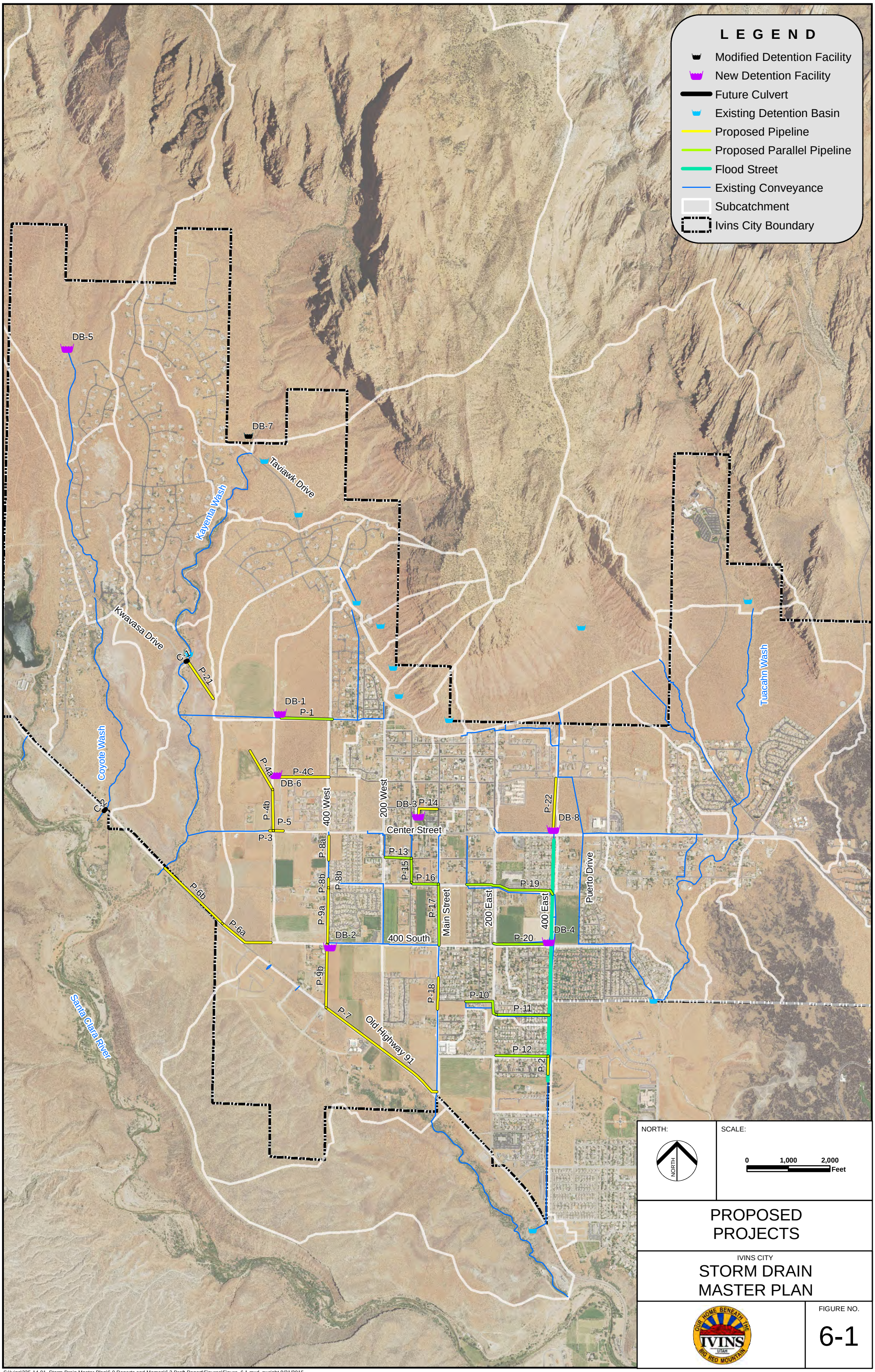
# CHAPTER 6
# RECOMMENDED SYSTEM IMPROVEMENTS

The results of the InfoSWMM model was used to evaluate various alternatives for mitigating the identified existing deficiencies and sizing future storm drain facilities under projected future development conditions. This chapter describes the storm drain improvements, based on estimated runoff and ground slopes.

## RECOMMENDED PIPELINE IMPROVEMENTS

Figure 6-1 shows the location of recommended pipeline improvements that are needed to meet future growth in Ivins City. A total cost for each project has been provided. Unit costs associated with the total project costs were developed based on past projects, master planning experience, and coordination with City personnel. A table showing these unit costs can be seen in Appendix C.

As can be seen in Figure 6-1 a combination of parallel and replacement projects are proposed. Determining between a parallel pipe and replacement was based on conversations with City personnel, as well as the size, material, condition, and age of the pipes. Table 6-1 summarizes the cost of the proposed pipe improvements in 2015 dollars. Costs for all projects have been divided into two priority groups. Priority 1 projects are planned to be constructed in the next 10-years, whereas priority 2 projects are low priority projects and are planned for some time after 2025. Conversations with City personnel were critical in identifying which projects had a higher priority.




S:\Ivins\235-14-01_Storm Drain Master Plan\6.0 Reports and Memos\6.2 Draft Report\Figures\Figure_6.1.mxd nwright 9/21/2015

**Table 6-1**
**Storm Drain Trunkline Improvements**

| Project ID | Project Location | Priority 1 (immediate) Estimated Cost | Priority 2 (future) Estimated Cost | Existing Pipe Size (in) | Future Pipe Size (in) | Existing Parallel Pipe Flow (cfs) | Future Flow/Release Rate (cfs) | Total Future Flow (cfs) | Description |
|---|---|---|---|---|---|---|---|---|---|
| P-1 | 450 N & Taviawk Dr. | $132,000 | $- | 24 | 24 | 19 | 19 | 38 | Future parallel 24" pipe |
| P-2 | 400 W & 825 S | $- | $129,800 | 36 | 48 | - | 112 | 112 | Replace 36" pipe with 48" pipe to meet level of service regarding spread. |
| P-3 | 600 W & Center Str. | $21,300 | $ - | 18 | 36 | - | 50 | 50 | Replace existing 18" with 36" pipe |
| P-4a | 600 W & 200 N | $142,100 | $- | - | 24 | - | 22 | 22 | New 24" pipe for future development |
| P-4b | 600 W & 100 N | $132,600 | $- | - | 24 | - | 27 | 27 | New 24" pipe for future development |
| P-4c** | 600 W & 200 N | $27,900 | $- | - | 24 | - | 29 | 29 | New 24" pipe for future development and to re-route existing flows west instead of south. |
| P-5 | 600 W & Center Str. | $36,900 | $- | 15 | 30 | - | 26 | 26 | Replace existing 15" to 30" pipe |
| P-6a* | 600 W & 400 S | $173,640 | $- | - | 24 | - | 19 | 19 | New 24" pipe for future development |
| P-6b* | 600 W & 400 S | $331,080 | $- | - | 30 | - | 45 | 45 | New 30" pipe for future development |

| Project ID | Project Location | Priority 1 (immediate) Estimated Cost | Priority 2 (future) Estimated Cost | Existing Pipe Size (in) | Future Pipe Size (in) | Existing Parallel Pipe Flow (cfs) | Future Flow/Release Rate (cfs) | Total Future Flow (cfs) | Description |
|---|---|---|---|---|---|---|---|---|---|
| P-7* | 200 W & Old Highway 91 | $648,480 | $- | - | 30 | - | 45 | 45 | New 30" pipe in place of swell. Pipe is approximately 20-30 ft deep at downstream end. |
| P-8a | 400 W & Center Str. | $65,200 | $- | - | 18 | - | 14 | 14 | New 18" line to connect systems. |
| P-8b | 400 W & 200 S | $34,400 | $- | 18-24 | 30 | - | 40 | 40 | Replace existing 18"-24" with 30" pipe |
| P-9a | 400 W & 400 S | $258,100 | $- | 24 | 36 | - | 55 | 55 | Replace existing 24" with 36" pipe |
| P-9b | 400 W & ~600 S | $153,600 | $- | - | 24 | - | 18 | 18 | New 24" to south. Install a flow control structure to force flows to the detention facility. |
| P-10 | 160 E & 625 S | $- | $166,000 | 24 | 24 | 15 | 19 | 34 | Future parallel 24" line |
| P-11 | 285 E & 650 S | $- | $249,700 | 24 | 30 | 20 | 31 | 51 | Future parallel 30" line |
| P-12 | 320 E & 800 S | $- | $209,000 | 18 | 24 | 13 | 20 | 33 | Future parallel 24" line |
| P-13 | 150 W & 100 S | $- | $103,800 | 24 | 24 | 12 | 18 | 30 | Future parallel 24" line |
| P-14 | 100 N & Main Str. | $- | $124,000 | - | 30 | - | 37 | 37 | Future 30" line to connect flows to future detention facility |

| Project ID | Project Location | Priority 1 (immediate) Estimated Cost | Priority 2 (future) Estimated Cost | Existing Pipe Size (in) | Future Pipe Size (in) | Existing Parallel Pipe Flow (cfs) | Future Flow/Release Rate (cfs) | Total Future Flow (cfs) | Description |
|---|---|---|---|---|---|---|---|---|---|
| P-15 | 100 W & 150 S | $- | $93,100 | 24 | 24 | 20 | 29 | 49 | Future parallel 24" line |
| P-16 | 200 S & Ivy Cir. | $148,700 | $- | 24 | 36 | 19 | 43 | 62 | Future parallel 36" line |
| P-17 | 350 S & Main Str. | $- | $281,100 | 24 | 30 | 24 | 42 | 66 | Future parallel 30" line |
| P-18 | 490 S & Main Str. | $- | $303,400 | 42 | 54 | - | 124 | 124 | Replace 42” with 54” pipe |
| P-19 | 250 E & 200 S | $- | $353,600 | 24 | 24 | 12 | 16 | 28 | Future parallel 24" line |
| P-20 | 250 E & 400 S | $- | $225,400 | 24 | 24 | 14 | 13 | 27 | Future parallel 24" line |
| P-21 | Paiute Dr. & Kwavasa Dr | $ 159,900 | $- | | 30 | - | 49 | 49 | New 30" pipe for future development |
| P-22 | 400 E & Center Str. | $- | $205,000 | | 24 | - | 0 | 0 | New 24" pipe for debris flows |
| | Trunkline Total | **$2,465,900** | **$2,443,900** | | | | | | |

* Unit Costs were multiplied by 1.2 due to the depth of pipe being deep.

** Cost paid for by developer. City is responsible for upsize from 18” to 24”.

## DETENTION BASIN IMPROVEMENTS

Figure 6-1 shows the location of recommended detention basin improvements that are needed to meet future growth in Ivins City. Table 6-2 lists the recommended detention volumes and costs for detention facilities in Ivins City.

**Table 6-2**
**Required Capacity at Detention Basins**

| Project ID | Project Location | Priority 1 (immediate) Estimated Cost | Priority 2 (future) Estimated Cost | Future Release Rate (cfs) | Storage Volume (ac-ft) | Description |
|---|---|---|---|---|---|---|
| DB-1 | 600 W & 450 N | $284,100 | $- | 18 | 2.7 | New 2.7 AF Detention Facility |
| DB-2 | 400 W & 400 S | $352,900 | $- | 18 | 3.5 | New 3.5 AF Detention Facility. Flows to be directed South instead of East as is the case for existing conditions. This will alleviate existing capacity issues in 400 S |
| DB-3 | City Park Baseball Field | $- | $214,000 | 15 | 4.2 | New 4.2 AF Detention Facility. Install inlets in 100 West to convey flows to detention facility |
| DB-4 | 400 E & 400 S | $370,100 | $- | 27 | 37 | New 3.7 AF Detention Facility |
| DB-5 | Northwest Mountain Watershed | $1,522,900 | $- | 170 | 21.8 | New 21.8 AF Detention Facility |
| DB-6 | 600 W & 200 N | $- | $206,600 | 6 | 1.8 | New 1.8 Detention Facility |
| DB-7 | Taviawk Dr. | $48,000 | $- | | 0 | Construct Emergency Spillway at existing road crossing |
| DB-8* | 400 E & Center Str. | $180,800 | $- | 14 | 6.0 | New 6.0 AF Detention Facility. Collect flows from Center Street and direct down 400 E. |
| | Detention Total | **$2,758,800** | **$420,600** | | | |

* Commercial Development will be required to participate in facility. Development responsible for cost to upsize from 4.5 AF to 6.0 AF.

## CULVERT IMPROVEMENTS

Figures 6-1 shows the location of recommended culvert improvements that are needed to meet future growth in Ivins City. Table 6-3 lists the recommended culvert sizes and costs needed in Ivins City.

**Table 6-3**
**Required Capacity at Culverts**

| Project ID | Project Location | Priority 1 (immediate) Estimated Cost | Priority 2 (future) Estimated Cost | Future Flow Rate (cfs) | Future Culvert Size (ft) | Existing Culvert Size (ft) | Project ID |
|---|---|---|---|---|---|---|---|
| C-1* | Kwavasa Dr. Culvert | $- | $- | 833 | 7'x9' | 7' | New 7' x 9' box culvert to replace existing 7' diameter pipe |
| C-2 | Coyote Gulch Culvert @ Old Hwy 91 | $69,120 | $- | 255 | 4'x10' | 48" | New 4' x 10' box culvert to replace existing 48" CMP |
| | Culvert Total | **$69,120** | **$-** | | | | |

* Developer responsible for the upsize of the culvert.

For a detailed cost estimate of each of the recommended improvements, see appendix C.

# APPENDIX A
# HYDROLOGIC DATA

## Table A-1: Subcatchment Runoff

| | | Existing Model Output | Future Model Output |
|---|---|---|---|
| ID | Subcatchment Area (ac) | Peak Runoff (cfs) | Peak Runoff (cfs) |
| I-1 | 2,637.36 | 688.277 | 689.948 |
| I-10 | 39.335 | 18.997 | 25.566 |
| I-11 | 98.053 | 12.692 | 38.687 |
| I-12 | 94.74 | 29.208 | 65.78 |
| I-13 | 80.446 | 34.55 | 71.753 |
| I-14 | 14.322 | 5.806 | 8.734 |
| I-15 | 363.436 | 47.893 | 47.893 |
| I-17 | 24.785 | 7.804 | 7.803 |
| I-18 | 26.032 | 12.596 | 20.891 |
| I-19 | 59.762 | 19.334 | 39.4 |
| I-2 | 1,061.95 | 319.416 | 324.128 |
| I-20 | 58.173 | 28.153 | 36.757 |
| I-21 | 54.903 | 22.741 | 32.396 |
| I-22 | 45.351 | 16.728 | 31.518 |
| I-23 | 38.97 | 19.202 | 24.956 |
| I-24 | 67.48 | 38.195 | 38.379 |
| I-25A | 50.842 | 13.328 | 13.328 |
| I-25B | 49.913 | 13.541 | 13.541 |
| I-26A | 83.52 | 10.444 | 10.444 |
| I-26B | 37.877 | 11.647 | 11.647 |
| I-27 | 26.452 | 11.98 | 14.811 |
| I-27A | 133.935 | 26.695 | 48.268 |
| I-28 | 123.526 | 9.39 | 50.003 |
| I-29 | 72.255 | 2.206 | 31.473 |
| I-3 | 399.656 | 56.328 | 179.091 |
| I-30 | 212.901 | 43.608 | 157.335 |
| I-31 | 285.997 | 36.657 | 254.388 |
| I-32 | 78.216 | 1.25 | 54.528 |
| I-33A | 101.012 | 11.263 | 33.615 |
| I-33B | 66.541 | 6.958 | 45.506 |
| I-33C | 37.824 | 27.249 | 27.249 |
| I-34 | 83.009 | 21.69 | 42.514 |
| I-35 | 79.632 | 13.11 | 37.757 |
| I-36A | 36.207 | 16.988 | 23.891 |
| I-36B | 45.082 | 26.144 | 26.144 |
| I-37 | 455.927 | 14.709 | 181.883 |
| I-38 | 442.649 | 10.313 | 10.324 |
| I-39 | 95.328 | 24.079 | 45.614 |
| I-4 | 175.458 | 103.358 | 127.397 |
| I-40 | 39.043 | 16.408 | 26.85 |
| I-40B | 44.873 | 11.629 | 25.501 |
| I-41 | 87.664 | 35.501 | 60.528 |
| I-42 | 117.254 | 33.992 | 72.733 |
| I-43 | 45.552 | 17.738 | 26.785 |
| I-44 | 49.719 | 31.95 | 32.216 |
| I-45 | 60.286 | 30.813 | 32.692 |
| I-46 | 46.128 | 29.07 | 34.907 |
| I-47 | 43.387 | 12.404 | 27.827 |
| I-48 | 30.015 | 18.641 | 18.659 |
| I-49 | 42.277 | 12.372 | 23.816 |
| I-5 | 295.864 | 193.801 | 212.168 |
| I-50 | 101.042 | 32.05 | 47.472 |
| I-51 | 81.334 | 52.196 | 52.362 |
| I-52 | 162.991 | 43.194 | 75.606 |
| I-53 | 83.59 | 3.353 | 48.983 |
| I-54 | 240.714 | 5.791 | 129.64 |
| I-55 | 78.016 | 30.576 | 45.682 |
| I-56 | 229.66 | 15.355 | 24.743 |
| I-57 | 28.197 | 18.255 | 21.095 |
| I-6 | 674.756 | 171.595 | 174.51 |
| I-7 | 665.473 | 233.213 | 401.551 |
| I-8 | 374.492 | 93.49 | 123.127 |
| I-9 | 71.649 | 5.121 | 5.985 |

GIS information needed to develop future master plans is available from Ivins City upon request.

# Table A-2: Valley Depths



Precipitation Frequency Data Server

**NOAA Atlas 14, Volume 1, Version 5**
**Location name: Ivins, Utah, US***
**Latitude: 37.1640°, Longitude: -113.6699°**
**Elevation: 3020 ft***
* source: Google Maps

**POINT PRECIPITATION FREQUENCY ESTIMATES**

Sanja Perica, Sarah Dietz, Sarah Heim, Lillian Hiner, Kazungu Maitaria, Deborah Martin, Sandra Pavlovic, Ishani Roy, Carl Trypaluk, Dale Unruh, Fenglin Yan, Michael Yekta, Tan Zhao, Geoffrey Bonnin, Daniel Brewer, Li-Chuan Chen, Tye Parzybok, John Yarchoan

NOAA, National Weather Service, Silver Spring, Maryland

PF_tabular | PF_graphical | Maps_&_aerials

## PF tabular

**PDS-based point precipitation frequency estimates with 90% confidence intervals (in inches)[1]**

| Duration | Average recurrence interval (years) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 5 | 10 | 25 | 50 | 100 | 200 | 500 | 1000 |
| 5-min | 0.134 (0.115-0.159) | 0.173 (0.148-0.206) | 0.234 (0.199-0.278) | 0.288 (0.244-0.344) | 0.372 (0.309-0.442) | 0.443 (0.363-0.528) | 0.526 (0.422-0.629) | 0.620 (0.484-0.746) | 0.764 (0.573-0.935) | 0.890 (0.648-1.10) |
| 10-min | 0.205 (0.175-0.242) | 0.263 (0.226-0.313) | 0.356 (0.303-0.424) | 0.438 (0.371-0.524) | 0.565 (0.470-0.673) | 0.674 (0.553-0.804) | 0.801 (0.642-0.958) | 0.943 (0.736-1.14) | 1.16 (0.872-1.42) | 1.35 (0.987-1.67) |
| 15-min | 0.254 (0.218-0.300) | 0.326 (0.279-0.388) | 0.442 (0.376-0.525) | 0.543 (0.460-0.649) | 0.701 (0.583-0.834) | 0.836 (0.685-0.996) | 0.993 (0.796-1.19) | 1.17 (0.912-1.41) | 1.44 (1.08-1.76) | 1.68 (1.22-2.07) |
| 30-min | 0.341 (0.291-0.404) | 0.439 (0.376-0.522) | 0.595 (0.507-0.708) | 0.732 (0.619-0.874) | 0.943 (0.785-1.12) | 1.13 (0.923-1.34) | 1.34 (1.07-1.60) | 1.57 (1.23-1.90) | 1.94 (1.46-2.37) | 2.26 (1.65-2.79) |
| 60-min | 0.423 (0.361-0.500) | 0.543 (0.466-0.646) | 0.736 (0.627-0.876) | 0.906 (0.766-1.08) | 1.17 (0.972-1.39) | 1.39 (1.14-1.66) | 1.65 (1.33-1.98) | 1.95 (1.52-2.35) | 2.40 (1.80-2.94) | 2.80 (2.04-3.45) |
| 2-hr | 0.513 (0.447-0.595) | 0.644 (0.562-0.749) | 0.846 (0.736-0.981) | 1.02 (0.886-1.19) | 1.30 (1.10-1.50) | 1.53 (1.28-1.77) | 1.79 (1.47-2.08) | 2.08 (1.67-2.45) | 2.53 (1.96-3.02) | 2.92 (2.20-3.53) |
| 3-hr | 0.570 (0.505-0.653) | 0.713 (0.632-0.819) | 0.920 (0.813-1.05) | 1.10 (0.963-1.25) | 1.36 (1.18-1.55) | 1.58 (1.35-1.81) | 1.83 (1.53-2.11) | 2.11 (1.73-2.46) | 2.54 (2.03-3.05) | 2.93 (2.28-3.56) |
| 6-hr | 0.709 (0.631-0.808) | 0.888 (0.795-1.01) | 1.13 (1.01-1.28) | 1.33 (1.18-1.52) | 1.62 (1.42-1.84) | 1.86 (1.60-2.12) | 2.12 (1.81-2.43) | 2.41 (2.02-2.79) | 2.86 (2.33-3.36) | 3.24 (2.58-3.85) |
| 12-hr | 0.866 (0.779-0.971) | 1.09 (0.975-1.22) | 1.37 (1.22-1.54) | 1.60 (1.43-1.80) | 1.91 (1.69-2.15) | 2.15 (1.88-2.43) | 2.40 (2.08-2.73) | 2.67 (2.29-3.06) | 3.05 (2.55-3.53) | 3.40 (2.79-3.97) |
| 24-hr | 1.02 (0.947-1.10) | 1.27 (1.18-1.37) | 1.59 (1.48-1.71) | 1.84 (1.71-1.98) | 2.19 (2.02-2.35) | 2.45 (2.26-2.63) | 2.73 (2.50-2.93) | 3.00 (2.73-3.23) | 3.38 (3.04-3.65) | 3.67 (3.27-4.00) |
| 2-day | 1.13 (1.05-1.21) | 1.41 (1.32-1.51) | 1.76 (1.64-1.88) | 2.04 (1.90-2.18) | 2.41 (2.24-2.58) | 2.71 (2.51-2.89) | 3.00 (2.77-3.22) | 3.31 (3.04-3.56) | 3.72 (3.38-4.01) | 4.04 (3.64-4.37) |
| 3-day | 1.22 (1.14-1.30) | 1.52 (1.42-1.63) | 1.89 (1.77-2.02) | 2.19 (2.05-2.34) | 2.59 (2.42-2.77) | 2.91 (2.70-3.10) | 3.23 (2.98-3.45) | 3.55 (3.27-3.81) | 3.99 (3.63-4.30) | 4.33 (3.91-4.69) |
| 4-day | 1.30 (1.22-1.40) | 1.63 (1.53-1.74) | 2.03 (1.90-2.17) | 2.35 (2.20-2.50) | 2.77 (2.60-2.96) | 3.11 (2.90-3.32) | 3.45 (3.20-3.69) | 3.80 (3.50-4.07) | 4.26 (3.89-4.59) | 4.63 (4.18-5.00) |
| 7-day | 1.51 (1.41-1.63) | 1.89 (1.76-2.03) | 2.35 (2.19-2.52) | 2.71 (2.53-2.90) | 3.20 (2.97-3.42) | 3.56 (3.30-3.81) | 3.94 (3.63-4.21) | 4.30 (3.95-4.63) | 4.79 (4.36-5.17) | 5.16 (4.66-5.59) |
| 10-day | 1.68 (1.56-1.81) | 2.10 (1.95-2.26) | 2.62 (2.44-2.81) | 3.02 (2.81-3.24) | 3.56 (3.30-3.81) | 3.96 (3.66-4.24) | 4.36 (4.02-4.68) | 4.76 (4.37-5.13) | 5.29 (4.81-5.71) | 5.68 (5.14-6.17) |
| 20-day | 2.12 (1.96-2.28) | 2.65 (2.46-2.85) | 3.27 (3.04-3.51) | 3.73 (3.46-4.00) | 4.30 (3.99-4.61) | 4.71 (4.36-5.05) | 5.11 (4.71-5.48) | 5.48 (5.03-5.89) | 5.93 (5.43-6.40) | 6.25 (5.70-6.76) |
| 30-day | 2.53 (2.34-2.73) | 3.17 (2.94-3.42) | 3.92 (3.64-4.22) | 4.48 (4.15-4.82) | 5.18 (4.80-5.58) | 5.69 (5.26-6.13) | 6.19 (5.70-6.67) | 6.66 (6.11-7.20) | 7.24 (6.61-7.85) | 7.66 (6.96-8.33) |
| 45-day | 3.02 (2.78-3.28) | 3.79 (3.49-4.11) | 4.72 (4.34-5.11) | 5.40 (4.97-5.85) | 6.28 (5.77-6.78) | 6.91 (6.34-7.47) | 7.52 (6.88-8.14) | 8.11 (7.40-8.79) | 8.82 (8.02-9.59) | 9.32 (8.45-10.2) |
| 60-day | 3.44 (3.16-3.75) | 4.32 (3.97-4.71) | 5.38 (4.94-5.84) | 6.15 (5.64-6.67) | 7.14 (6.53-7.74) | 7.84 (7.16-8.51) | 8.52 (7.75-9.26) | 9.16 (8.32-9.97) | 9.96 (9.00-10.9) | 10.5 (9.46-11.5) |

[1] Precipitation frequency (PF) estimates in this table are based on frequency analysis of partial duration series (PDS).

Numbers in parenthesis are PF estimates at lower and upper bounds of the 90% confidence interval. The probability that precipitation frequency estimates (for a given duration and average recurrence interval) will be greater than the upper bound (or less than the lower bound) is 5%. Estimates at upper bounds are not checked against probable maximum precipitation (PMP) estimates and may be higher than currently valid PMP values.

Please refer to NOAA Atlas 14 document for more information.

Back to Top

## PF graphical

# Table A-3: Central Depths

3/9/2015 Precipitation Frequency Data Server

**NOAA Atlas 14, Volume 1, Version 5**
**Location name: Dammeron Valley, Utah, US***
**Latitude: 37.1795°, Longitude: -113.6790°**
**Elevation: 3767 ft***
*source: Google Maps

**POINT PRECIPITATION FREQUENCY ESTIMATES**

Sanja Perica, Sarah Dietz, Sarah Heim, Lillian Hiner, Kazungu Maitaria, Deborah Martin, Sandra Pavlovic, Ishani Roy, Carl Trypaluk, Dale Unruh, Fenglin Yan, Michael Yekta, Tan Zhao, Geoffrey Bonnin, Daniel Brewer, Li-Chuan Chen, Tye Parzybok, John Yarchoan

NOAA, National Weather Service, Silver Spring, Maryland

PF_tabular | PF_graphical | Maps_&_aerials

## PF tabular

**PDS-based point precipitation frequency estimates with 90% confidence intervals (in inches)[1]**

| Duration | Average recurrence interval (years) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 5 | 10 | 25 | 50 | 100 | 200 | 500 | 1000 |
| 5-min | 0.140 (0.120-0.166) | 0.180 (0.154-0.215) | 0.244 (0.208-0.291) | 0.300 (0.253-0.360) | 0.386 (0.320-0.461) | 0.460 (0.376-0.550) | 0.545 (0.436-0.654) | 0.641 (0.499-0.774) | 0.789 (0.591-0.969) | 0.919 (0.668-1.14) |
| 10-min | 0.214 (0.182-0.253) | 0.274 (0.235-0.327) | 0.372 (0.316-0.444) | 0.457 (0.385-0.548) | 0.587 (0.488-0.702) | 0.700 (0.572-0.837) | 0.829 (0.663-0.995) | 0.975 (0.760-1.18) | 1.20 (0.900-1.47) | 1.40 (1.02-1.73) |
| 15-min | 0.265 (0.226-0.313) | 0.340 (0.291-0.406) | 0.461 (0.392-0.550) | 0.567 (0.478-0.679) | 0.728 (0.604-0.870) | 0.867 (0.709-1.04) | 1.03 (0.823-1.23) | 1.21 (0.942-1.46) | 1.49 (1.11-1.83) | 1.73 (1.26-2.15) |
| 30-min | 0.356 (0.304-0.422) | 0.458 (0.392-0.546) | 0.620 (0.527-0.741) | 0.762 (0.643-0.914) | 0.981 (0.814-1.17) | 1.17 (0.955-1.40) | 1.38 (1.11-1.66) | 1.63 (1.27-1.97) | 2.00 (1.50-2.46) | 2.33 (1.70-2.89) |
| 60-min | 0.441 (0.376-0.522) | 0.567 (0.485-0.676) | 0.768 (0.653-0.917) | 0.944 (0.796-1.13) | 1.21 (1.01-1.45) | 1.45 (1.18-1.73) | 1.71 (1.37-2.06) | 2.02 (1.57-2.43) | 2.48 (1.86-3.04) | 2.89 (2.10-3.58) |
| 2-hr | 0.530 (0.461-0.617) | 0.666 (0.580-0.776) | 0.874 (0.759-1.02) | 1.06 (0.912-1.23) | 1.34 (1.14-1.55) | 1.58 (1.32-1.83) | 1.85 (1.51-2.16) | 2.15 (1.72-2.54) | 2.61 (2.02-3.12) | 3.01 (2.26-3.64) |
| 3-hr | 0.592 (0.523-0.679) | 0.742 (0.655-0.852) | 0.955 (0.841-1.10) | 1.14 (0.997-1.30) | 1.41 (1.22-1.62) | 1.64 (1.39-1.88) | 1.90 (1.59-2.19) | 2.18 (1.79-2.55) | 2.63 (2.09-3.15) | 3.03 (2.35-3.68) |
| 6-hr | 0.737 (0.655-0.839) | 0.922 (0.824-1.05) | 1.18 (1.04-1.33) | 1.38 (1.22-1.58) | 1.68 (1.47-1.92) | 1.93 (1.66-2.21) | 2.20 (1.87-2.53) | 2.50 (2.09-2.90) | 2.96 (2.41-3.48) | 3.35 (2.67-3.98) |
| 12-hr | 0.903 (0.811-1.01) | 1.13 (1.01-1.27) | 1.43 (1.27-1.60) | 1.67 (1.48-1.88) | 1.99 (1.76-2.24) | 2.24 (1.96-2.54) | 2.51 (2.17-2.85) | 2.78 (2.38-3.19) | 3.18 (2.66-3.68) | 3.54 (2.91-4.14) |
| 24-hr | 1.07 (0.992-1.16) | 1.34 (1.24-1.44) | 1.67 (1.55-1.80) | 1.94 (1.80-2.09) | 2.30 (2.13-2.48) | 2.58 (2.39-2.78) | 2.87 (2.63-3.09) | 3.17 (2.88-3.42) | 3.56 (3.21-3.86) | 3.87 (3.46-4.20) |
| 2-day | 1.19 (1.11-1.28) | 1.49 (1.39-1.60) | 1.86 (1.74-2.00) | 2.16 (2.01-2.31) | 2.57 (2.38-2.75) | 2.88 (2.66-3.09) | 3.21 (2.95-3.45) | 3.54 (3.24-3.81) | 3.99 (3.61-4.32) | 4.34 (3.90-4.72) |
| 3-day | 1.29 (1.21-1.39) | 1.62 (1.51-1.74) | 2.02 (1.89-2.17) | 2.34 (2.19-2.51) | 2.78 (2.59-2.98) | 3.13 (2.90-3.35) | 3.48 (3.20-3.73) | 3.84 (3.51-4.13) | 4.33 (3.92-4.68) | 4.71 (4.23-5.11) |
| 4-day | 1.39 (1.30-1.50) | 1.74 (1.63-1.87) | 2.18 (2.04-2.33) | 2.53 (2.36-2.70) | 3.00 (2.79-3.21) | 3.37 (3.13-3.61) | 3.75 (3.46-4.02) | 4.14 (3.79-4.45) | 4.66 (4.23-5.04) | 5.07 (4.56-5.50) |
| 7-day | 1.63 (1.51-1.75) | 2.03 (1.89-2.19) | 2.54 (2.36-2.73) | 2.94 (2.73-3.16) | 3.49 (3.22-3.74) | 3.90 (3.59-4.18) | 4.32 (3.96-4.64) | 4.74 (4.32-5.11) | 5.30 (4.79-5.75) | 5.73 (5.14-6.24) |
| 10-day | 1.81 (1.68-1.95) | 2.27 (2.10-2.45) | 2.84 (2.63-3.06) | 3.29 (3.04-3.53) | 3.88 (3.58-4.17) | 4.32 (3.98-4.66) | 4.78 (4.38-5.16) | 5.23 (4.77-5.66) | 5.83 (5.28-6.34) | 6.28 (5.65-6.87) |
| 20-day | 2.29 (2.12-2.47) | 2.88 (2.67-3.11) | 3.56 (3.30-3.84) | 4.07 (3.77-4.37) | 4.70 (4.34-5.06) | 5.16 (4.76-5.56) | 5.61 (5.15-6.04) | 6.03 (5.52-6.52) | 6.56 (5.97-7.11) | 6.93 (6.28-7.53) |
| 30-day | 2.75 (2.54-2.98) | 3.45 (3.19-3.74) | 4.29 (3.96-4.63) | 4.91 (4.54-5.30) | 5.70 (5.26-6.16) | 6.28 (5.77-6.79) | 6.84 (6.26-7.40) | 7.38 (6.73-8.01) | 8.06 (7.31-8.77) | 8.55 (7.72-9.34) |
| 45-day | 3.28 (3.02-3.58) | 4.13 (3.79-4.50) | 5.16 (4.73-5.61) | 5.92 (5.43-6.44) | 6.90 (6.32-7.50) | 7.62 (6.96-8.28) | 8.32 (7.57-9.06) | 9.00 (8.16-9.82) | 9.85 (8.88-10.8) | 10.5 (9.40-11.5) |
| 60-day | 3.76 (3.44-4.10) | 4.73 (4.33-5.16) | 5.90 (5.40-6.44) | 6.76 (6.18-7.37) | 7.87 (7.17-8.57) | 8.67 (7.87-9.45) | 9.45 (8.55-10.3) | 10.2 (9.19-11.1) | 11.1 (9.98-12.2) | 11.8 (10.5-13.0) |

[1] Precipitation frequency (PF) estimates in this table are based on frequency analysis of partial duration series (PDS).

Numbers in parenthesis are PF estimates at lower and upper bounds of the 90% confidence interval. The probability that precipitation frequency estimates (for a given duration and average recurrence interval) will be greater than the upper bound (or less than the lower bound) is 5%. Estimates at upper bounds are not checked against probable maximum precipitation (PMP) estimates and may be higher than currently valid PMP values.

Please refer to NOAA Atlas 14 document for more information.

Back to Top

## PF graphical

# Table A-4: Mountain Depths

3/9/2015 Precipitation Frequency Data Server

**NOAA Atlas 14, Volume 1, Version 5**
**Location name: Dammeron Valley, Utah, US***
**Latitude: 37.2389°, Longitude: -113.7011°**
**Elevation: 5037 ft***
* source: Google Maps

**POINT PRECIPITATION FREQUENCY ESTIMATES**

Sanja Perica, Sarah Dietz, Sarah Heim, Lillian Hiner, Kazungu Maitaria, Deborah Martin, Sandra Pavlovic, Ishani Roy, Carl Trypaluk, Dale Unruh, Fenglin Yan, Michael Yekta, Tan Zhao, Geoffrey Bonnin, Daniel Brewer, Li-Chuan Chen, Tye Parzybok, John Yarchoan

NOAA, National Weather Service, Silver Spring, Maryland

PF_tabular | PF_graphical | Maps_&_aerials

## PF tabular

**PDS-based point precipitation frequency estimates with 90% confidence intervals (in inches)[1]**

| Duration | Average recurrence interval (years) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 5 | 10 | 25 | 50 | 100 | 200 | 500 | 1000 |
| 5-min | 0.154 (0.130-0.184) | 0.198 (0.168-0.239) | 0.268 (0.225-0.322) | 0.329 (0.274-0.397) | 0.420 (0.345-0.507) | 0.499 (0.404-0.603) | 0.589 (0.468-0.714) | 0.691 (0.534-0.844) | 0.848 (0.632-1.05) | 0.987 (0.714-1.24) |
| 10-min | 0.235 (0.199-0.281) | 0.302 (0.256-0.363) | 0.407 (0.343-0.491) | 0.500 (0.417-0.605) | 0.639 (0.526-0.772) | 0.759 (0.615-0.918) | 0.896 (0.712-1.09) | 1.05 (0.814-1.28) | 1.29 (0.962-1.60) | 1.50 (1.09-1.88) |
| 15-min | 0.291 (0.247-0.348) | 0.374 (0.317-0.450) | 0.505 (0.425-0.609) | 0.621 (0.517-0.750) | 0.793 (0.651-0.958) | 0.941 (0.763-1.14) | 1.11 (0.882-1.35) | 1.30 (1.01-1.59) | 1.60 (1.19-1.98) | 1.86 (1.35-2.33) |
| 30-min | 0.392 (0.332-0.468) | 0.504 (0.427-0.606) | 0.680 (0.572-0.820) | 0.836 (0.696-1.01) | 1.07 (0.877-1.29) | 1.27 (1.03-1.53) | 1.50 (1.19-1.81) | 1.75 (1.36-2.14) | 2.15 (1.61-2.67) | 2.51 (1.81-3.14) |
| 60-min | 0.485 (0.411-0.580) | 0.624 (0.528-0.751) | 0.842 (0.709-1.01) | 1.03 (0.862-1.25) | 1.32 (1.09-1.60) | 1.57 (1.27-1.90) | 1.85 (1.47-2.25) | 2.17 (1.68-2.65) | 2.67 (1.99-3.31) | 3.10 (2.25-3.89) |
| 2-hr | 0.577 (0.500-0.678) | 0.728 (0.627-0.855) | 0.953 (0.818-1.12) | 1.15 (0.982-1.35) | 1.45 (1.22-1.71) | 1.71 (1.41-2.00) | 2.00 (1.62-2.36) | 2.32 (1.84-2.77) | 2.81 (2.16-3.39) | 3.24 (2.42-3.95) |
| 3-hr | 0.652 (0.573-0.754) | 0.818 (0.716-0.945) | 1.05 (0.916-1.21) | 1.25 (1.08-1.44) | 1.54 (1.32-1.78) | 1.79 (1.51-2.08) | 2.07 (1.72-2.41) | 2.38 (1.94-2.79) | 2.86 (2.27-3.43) | 3.28 (2.55-3.99) |
| 6-hr | 0.814 (0.719-0.934) | 1.02 (0.905-1.17) | 1.29 (1.14-1.48) | 1.52 (1.33-1.75) | 1.85 (1.60-2.12) | 2.12 (1.81-2.44) | 2.40 (2.04-2.78) | 2.73 (2.28-3.19) | 3.23 (2.63-3.81) | 3.65 (2.90-4.36) |
| 12-hr | 1.00 (0.897-1.13) | 1.26 (1.12-1.42) | 1.58 (1.41-1.79) | 1.85 (1.64-2.10) | 2.21 (1.94-2.50) | 2.49 (2.17-2.83) | 2.78 (2.40-3.19) | 3.09 (2.63-3.56) | 3.53 (2.95-4.10) | 3.92 (3.22-4.61) |
| 24-hr | 1.20 (1.11-1.29) | 1.50 (1.40-1.62) | 1.88 (1.75-2.03) | 2.19 (2.03-2.36) | 2.60 (2.40-2.80) | 2.93 (2.69-3.14) | 3.26 (2.98-3.50) | 3.59 (3.26-3.87) | 4.05 (3.64-4.38) | 4.41 (3.92-4.77) |
| 2-day | 1.35 (1.26-1.46) | 1.70 (1.58-1.83) | 2.13 (1.99-2.29) | 2.49 (2.31-2.67) | 2.97 (2.75-3.19) | 3.35 (3.09-3.60) | 3.74 (3.43-4.03) | 4.15 (3.78-4.48) | 4.71 (4.24-5.10) | 5.14 (4.60-5.60) |
| 3-day | 1.49 (1.39-1.60) | 1.87 (1.74-2.01) | 2.36 (2.19-2.53) | 2.75 (2.55-2.95) | 3.28 (3.04-3.52) | 3.70 (3.41-3.98) | 4.14 (3.79-4.46) | 4.59 (4.17-4.95) | 5.20 (4.68-5.64) | 5.68 (5.07-6.19) |
| 4-day | 1.63 (1.51-1.75) | 2.04 (1.90-2.20) | 2.58 (2.40-2.77) | 3.01 (2.79-3.23) | 3.59 (3.32-3.86) | 4.06 (3.73-4.36) | 4.53 (4.15-4.88) | 5.03 (4.57-5.43) | 5.69 (5.12-6.18) | 6.22 (5.54-6.79) |
| 7-day | 1.93 (1.78-2.08) | 2.42 (2.24-2.62) | 3.06 (2.82-3.30) | 3.56 (3.28-3.84) | 4.25 (3.90-4.58) | 4.78 (4.37-5.15) | 5.32 (4.83-5.75) | 5.88 (5.30-6.38) | 6.63 (5.92-7.22) | 7.21 (6.39-7.89) |
| 10-day | 2.16 (1.99-2.34) | 2.72 (2.51-2.95) | 3.43 (3.17-3.71) | 3.99 (3.67-4.30) | 4.73 (4.34-5.11) | 5.30 (4.84-5.74) | 5.88 (5.34-6.38) | 6.47 (5.84-7.04) | 7.25 (6.50-7.92) | 7.86 (6.99-8.63) |
| 20-day | 2.78 (2.56-3.01) | 3.50 (3.23-3.79) | 4.36 (4.01-4.71) | 4.99 (4.59-5.39) | 5.79 (5.31-6.26) | 6.38 (5.83-6.90) | 6.95 (6.33-7.54) | 7.60 (6.80-8.15) | 8.21 (7.40-8.94) | 8.71 (7.82-9.51) |
| 30-day | 3.36 (3.09-3.66) | 4.24 (3.90-4.62) | 5.30 (4.88-5.77) | 6.10 (5.59-6.64) | 7.12 (6.52-7.76) | 7.87 (7.18-8.59) | 8.62 (7.82-9.41) | 9.34 (8.44-10.2) | 10.3 (9.22-11.3) | 11.0 (9.79-12.1) |
| 45-day | 4.02 (3.67-4.41) | 5.08 (4.64-5.57) | 6.38 (5.82-7.00) | 7.36 (6.70-8.07) | 8.63 (7.83-9.47) | 9.58 (8.66-10.5) | 10.5 (9.48-11.6) | 11.5 (10.3-12.6) | 12.7 (11.3-14.0) | 13.6 (12.0-15.1) |
| 60-day | 4.64 (4.22-5.10) | 5.87 (5.34-6.45) | 7.38 (6.70-8.10) | 8.48 (7.69-9.30) | 9.90 (8.94-10.9) | 10.9 (9.85-12.0) | 12.0 (10.7-13.2) | 13.0 (11.6-14.3) | 14.3 (12.7-15.8) | 15.2 (13.4-16.9) |

[1] Precipitation frequency (PF) estimates in this table are based on frequency analysis of partial duration series (PDS).

Numbers in parenthesis are PF estimates at lower and upper bounds of the 90% confidence interval. The probability that precipitation frequency estimates (for a given duration and average recurrence interval) will be greater than the upper bound (or less than the lower bound) is 5%. Estimates at upper bounds are not checked against probable maximum precipitation (PMP) estimates and may be higher than currently valid PMP values.

Please refer to NOAA Atlas 14 document for more information.

Back to Top

## PF graphical

**LEGEND**

- Subcatchment Boundary
- Ivins City Boundary
- 10' Contours

I-1
I-2
I-3
I-4
I-5
I-6
I-7
I-8
I-9
I-10
I-11
I-12
I-13
I-14
I-15
I-17
I-18
I-19
I-20
I-21
I-22
I-23
I-24
I-25A
I-25B
I-26A
I-26B
I-27
I-27A
I-28
I-29
I-30
I-31
I-32
I-33A
I-33B
I-33C
I-34
I-35
I-36A
I-36B
I-37
I-38
I-39
I-40
I-40B
I-41
I-42
I-43
I-44
I-45
I-46
I-47
I-48
I-49
I-50
I-51
I-52
I-53
I-54
I-55
I-56
I-57

Taviawk Drive
Kwavasa Drive
Center Street
400 South
400 West
200 West
Main Street
200 East
400 East
Puerto Drive
Old Highway 91

NORTH:

SCALE: 0 1,250 2,500 Feet

# SUBCATCHMENT BOUNDARIES

IVINS CITY
STORM DRAIN MASTER PLAN

FIGURE NO.
A-1

S:\Ivins\235-14-01_Storm Drain Master Plan\6.0 Reports and Memos\6.2 Draft Report\Appendices\Appendix A\Figure_A-1.mxd nwright 9/21/2015




S:\Ivins\235-14-01_Storm Drain Master Plan\6.0 Reports and Memos\6.2 Draft Report\Appendices\Appendix A\Figure_A-2.mxd nwright 9/21/2015




# HYDROLOGIC SOIL GROUP

IVINS CITY

## STORM DRAIN MASTER PLAN

FIGURE NO.

A-3

S:\Ivins\235-14-01_Storm Drain Master Plan\6.0 Reports and Memos\6.2 Draft Report\Appendices\Appendix A\Figure_A-3.mxd nwright 9/21/2015

**L E G E N D**

Subcatchment

**Antecedant Moisture Condition**

AMC II

AMC III

Taviawk Drive

Kwavasa Drive

Lava Flow

Center Street

400 West

200 West

Main Street

200 East

400 East

Puerto Drive

400 South

Old Highway 91

NORTH:

NORTH

SCALE:

0 1,250 2,500 Feet

# ANTECEDENT MOISTURE CONTENT

IVINS CITY

## STORM DRAIN MASTER PLAN

FIGURE NO.

A-4

S:\Ivins\235-14-01_Storm Drain Master Plan\6.0 Reports and Memos\6.2 Draft Report\Appendices\Appendix A\Figure_A-4.mxd nwright 9/21/2015

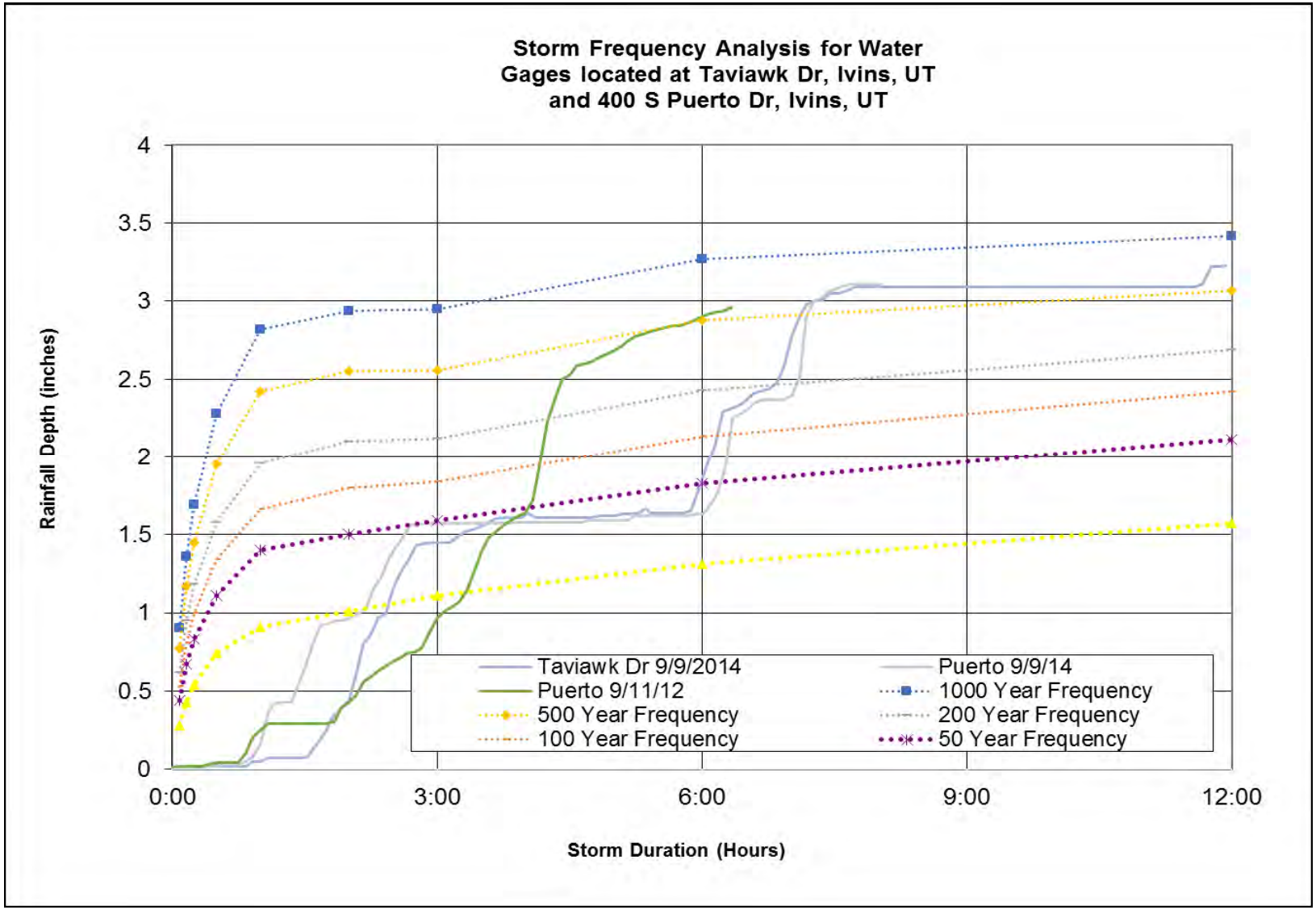
# APPENDIX B
# LARGE STORM EVENTS

## Recent Large Storm Event Narrative

Recently Ivins City has seen two storm events larger than a 500-year storm. Figure B-1 shows the cumulative depth for the two largest storms measured from local rain depth gauges in the city. These storms were entered into the Info SWMM model and used to calibrate the mountain watersheds. A comparison of measured field data and model output can be seen in Table 3-3 of this report. Based on the results presented in the table it can be seen that model output mirror the measured field data fairly well.

A table showing the precipitation measured at two different local gauges can be seen in Tables B-1 through B-3. Graphs for each of these tables can be seen in Figures B-2 through B-4. It can be seen in the graphs that multiple large peaks appear to occur in each of these events. The double peaks lead to saturated soils which leads to larger runoffs. To account for the saturated soils certain areas have used AMC III curve numbers instead of the AMC II which is the normal soil condition. Due to the steeper slopes and limited development this will be more important in the mountain watershed areas. Figure A-3 in this report shows the location where the two AMC values were used. Table 3-1 in this report gives the different curve numbers used for each AMC.

**Figure B-1: Storm Frequency Comparison**

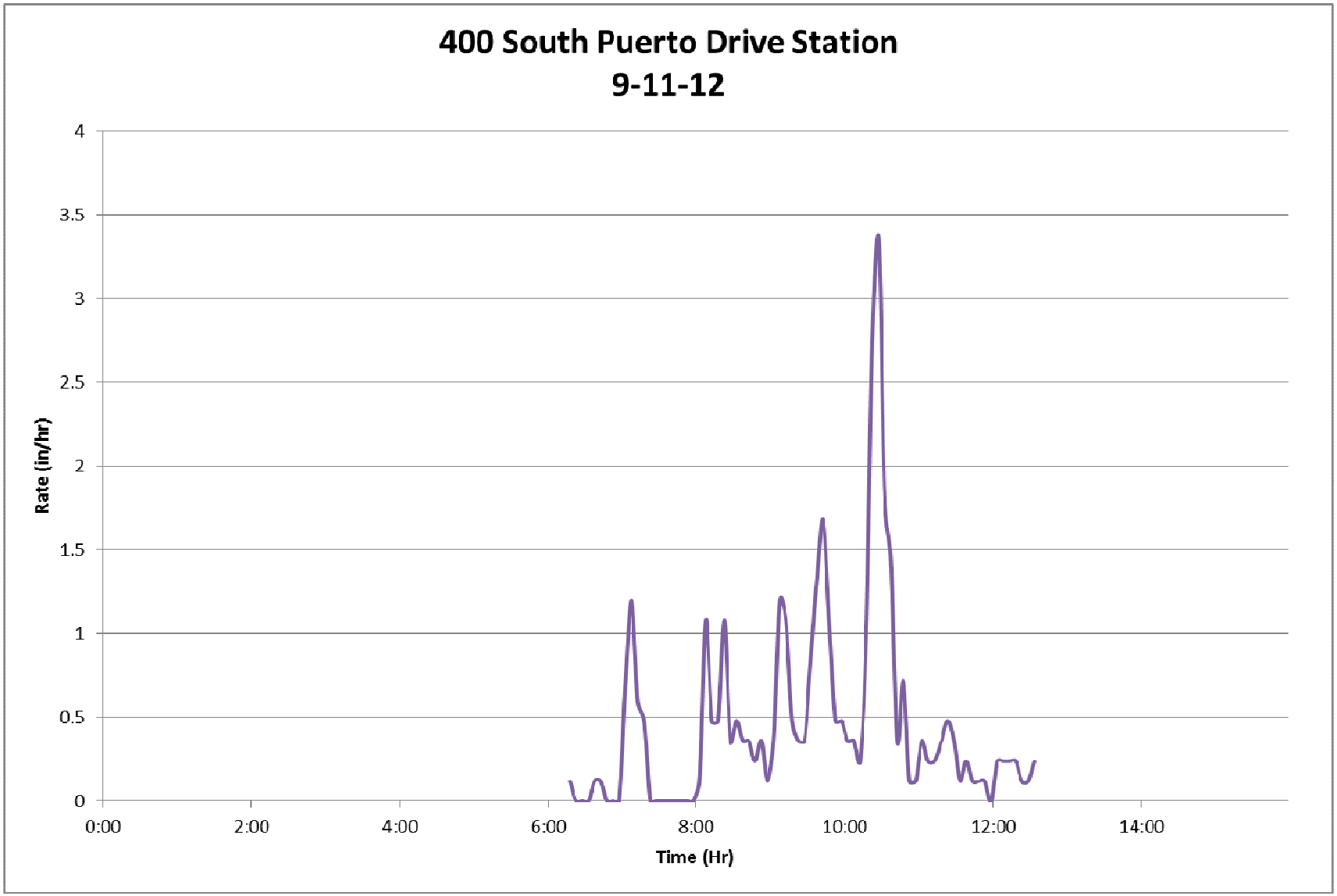


# 9-11-2012 Storm Event

**Table B-1: 9-11-12 Rainfall Data @ 400 S Puerto Drive Station**

| Time | Rate (in/hr) | Total Runoff (in) | Time | Rate (in/hr) | Total Runoff (in) | Time | Rate (in/hr) | Total Runoff (in) |
|---|---|---|---|---|---|---|---|---|
| 6:18 | 0 | 0.01 | 8:28 | 1.08 | 0.56 | 10:38 | 1.8 | 2.38 |
| 6:23 | 0.12 | 0.02 | 8:33 | 0.36 | 0.59 | 10:43 | 1.44 | 2.5 |
| 6:28 | 0 | 0.02 | 8:38 | 0.48 | 0.63 | 10:48 | 0.36 | 2.53 |
| 6:33 | 0 | 0.02 | 8:43 | 0.36 | 0.66 | 10:53 | 0.72 | 2.59 |
| 6:38 | 0 | 0.02 | 8:48 | 0.36 | 0.69 | 10:58 | 0.12 | 2.6 |
| 6:43 | 0.12 | 0.03 | 8:53 | 0.24 | 0.71 | 11:03 | 0.12 | 2.61 |
| 6:48 | 0.12 | 0.04 | 8:58 | 0.36 | 0.74 | 11:08 | 0.36 | 2.64 |
| 6:53 | 0 | 0.04 | 9:03 | 0.12 | 0.75 | 11:13 | 0.24 | 2.66 |
| 6:58 | 0 | 0.04 | 9:08 | 0.36 | 0.78 | 11:19 | 0.24 | 2.68 |
| 7:03 | 0 | 0.04 | 9:13 | 1.2 | 0.88 | 11:24 | 0.36 | 2.71 |
| 7:08 | 0.72 | 0.1 | 9:18 | 1.08 | 0.97 | 11:29 | 0.48 | 2.75 |
| 7:13 | 1.2 | 0.2 | 9:23 | 0.48 | 1.01 | 11:34 | 0.36 | 2.78 |
| 7:18 | 0.6 | 0.25 | 0.39 | 0.36 | 1.04 | 11:39 | 0.12 | 2.79 |
| 7:23 | 0.48 | 0.29 | 9:33 | 0.36 | 1.07 | 11:44 | 0.24 | 2.81 |
| 7:28 | 0 | 0.29 | 9:38 | 0.84 | 1.14 | 11:49 | 0.12 | 2.82 |
| 7:33 | 0 | 0.29 | 9:43 | 1.32 | 1.25 | 11:54 | 0.12 | 2.83 |
| 7:38 | 0 | 0.29 | 9:48 | 1.68 | 1.39 | 11:59 | 0.12 | 2.84 |
| 7:43 | 0 | 0.29 | 9:53 | 1.08 | 1.48 | 12:04 | 0 | 2.84 |
| 7:48 | 0 | 0.29 | 9:58 | 0.48 | 1.52 | 12:09 | 0.24 | 2.86 |
| 7:53 | 0 | 0.29 | 10:03 | 0.48 | 1.56 | 12:14 | 0.24 | 2.88 |
| 7:58 | 0 | 0.29 | 10:08 | 0.36 | 1.59 | 12:19 | 0.24 | 2.9 |
| 8:03 | 0 | 0.29 | 10:13 | 0.36 | 1.62 | 12:24 | 0.24 | 2.92 |
| 8:08 | 0.12 | 0.3 | 10:18 | 0.24 | 1.64 | 12:29 | 0.12 | 2.93 |
| 8:13 | 1.08 | 0.39 | 10:23 | 0.96 | 1.72 | 12:34 | 0.12 | 2.94 |
| 8:18 | 0.48 | 0.43 | 10:28 | 2.76 | 1.95 | 12:39 | 0.24 | 2.96 |
| 8:23 | 0.48 | 0.47 | 10:33 | 3.36 | 2.23 | | | |

**Figure B-2: 400 South and Puerto Drive Precipitation graph from 9/11/12**

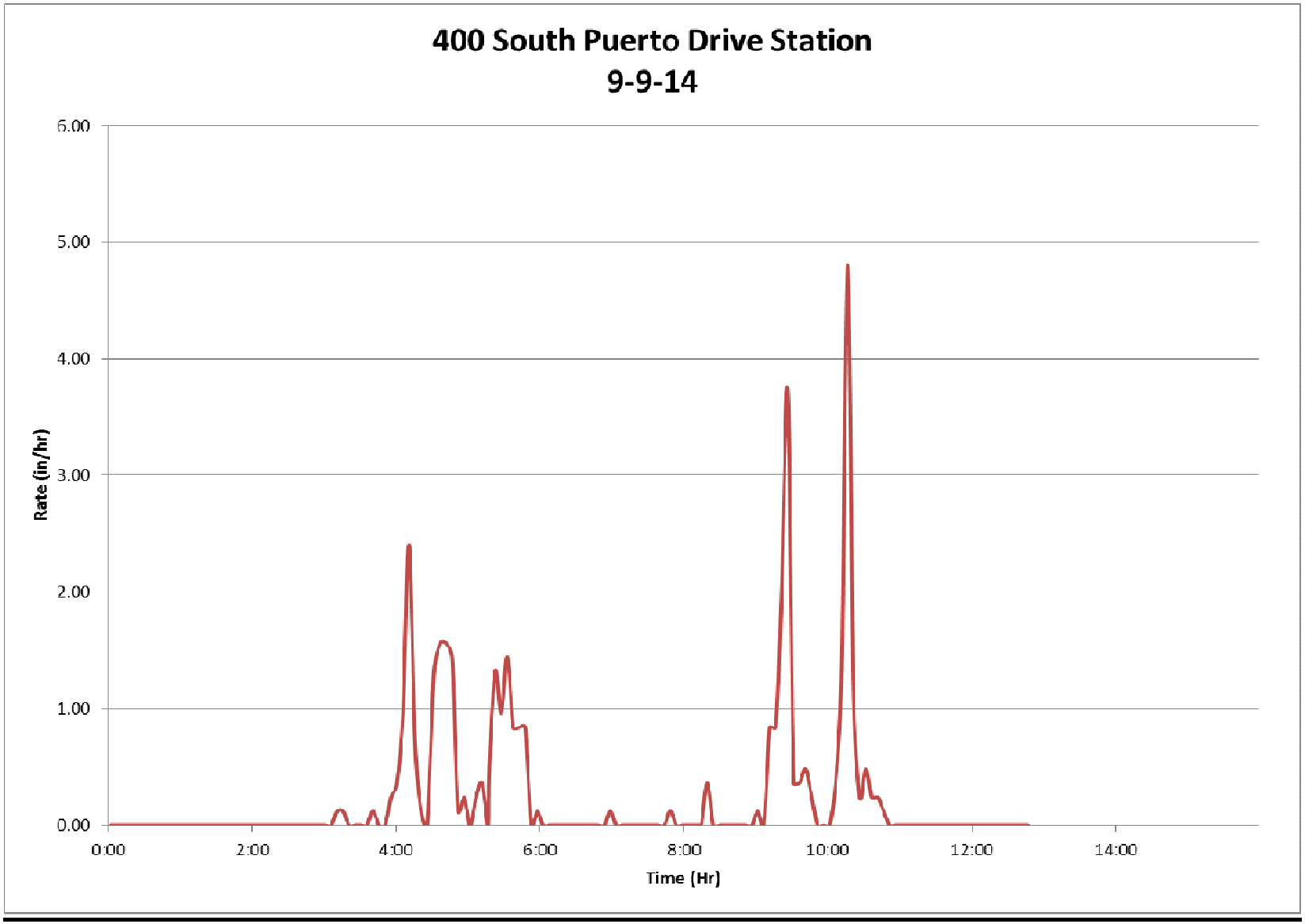


# 9-9-2014 Storm Event

**Table B-2: 9-9-14 Rainfall Data @ 400 S Puerto Drive Station**

| Time | Rate (in/hr) | Total Runoff (in) | Time | Rate (in/hr) | Total Runoff (in) | Time | Rate (in/hr) | Total Runoff (in) | Time | Rate (in/hr) | Total Runoff (in) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 3:16 | 0.12 | 0.01 | 5:38 | 1.44 | 1.35 | 8:04 | 0.00 | 1.59 | 10:22 | 4.80 | 2.91 |
| 3:21 | 0.12 | 0.02 | 5:43 | 0.84 | 1.42 | 8:09 | 0.00 | 1.59 | 10:27 | 1.08 | 3.00 |
| 3:26 | 0.00 | 0.02 | 5:48 | 0.84 | 1.49 | 8:14 | 0.00 | 1.59 | 10:32 | 0.24 | 3.02 |
| 3:31 | 0.00 | 0.02 | 5:53 | 0.84 | 1.56 | 8:15 | 0.00 | 1.59 | 10:37 | 0.48 | 3.06 |
| 3:36 | 0.00 | 0.02 | 5:58 | 0.00 | 1.56 | 8:20 | 0.00 | 1.59 | 10:42 | 0.24 | 3.08 |
| 3:41 | 0.00 | 0.02 | 6:03 | 0.12 | 1.57 | 8:25 | 0.36 | 1.62 | 10:47 | 0.24 | 3.10 |
| 3:46 | 0.12 | 0.03 | 6:08 | 0.00 | 1.57 | 8:30 | 0.00 | 1.62 | 10:52 | 0.12 | 3.11 |
| 3:51 | 0.00 | 0.03 | 6:13 | 0.00 | 1.57 | 8:35 | 0.00 | 1.62 | 10:57 | 0.00 | 3.11 |
| 3:56 | 0.00 | 0.03 | 6:18 | 0.00 | 1.57 | 8:37 | 0.00 | 1.62 | 11:02 | 0.00 | 3.11 |
| 4:01 | 0.24 | 0.05 | 6:23 | 0.00 | 1.57 | 8:42 | 0.00 | 1.62 | 11:07 | 0.00 | 3.11 |
| 4:06 | 0.36 | 0.08 | 6:28 | 0.00 | 1.57 | 8:47 | 0.00 | 1.62 | 11:12 | 0.00 | 3.11 |
| 4:11 | 0.96 | 0.16 | 6:33 | 0.00 | 1.57 | 8:52 | 0.00 | 1.62 | 11:17 | 0.00 | 3.11 |
| 4:16 | 2.40 | 0.36 | 6:38 | 0.00 | 1.57 | 8:57 | 0.00 | 1.62 | 11:22 | 0.00 | 3.11 |
| 4:21 | 0.72 | 0.42 | 6:43 | 0.00 | 1.57 | 9:02 | 0.00 | 1.62 | 11:27 | 0.00 | 3.11 |
| 4:26 | 0.12 | 0.43 | 6:49 | 0.00 | 1.57 | 9:07 | 0.12 | 1.63 | 11:33 | 0.00 | 3.11 |
| 4:32 | 0.00 | 0.43 | 6:54 | 0.00 | 1.57 | 9:12 | 0.00 | 1.63 | 11:38 | 0.00 | 3.11 |
| 4:37 | 1.32 | 0.54 | 6:59 | 0.00 | 1.57 | 9:17 | 0.84 | 1.70 | 11:43 | 0.00 | 3.11 |
| 4:42 | 1.56 | 0.67 | 7:04 | 0.12 | 1.58 | 9:22 | 0.84 | 1.77 | 11:48 | 0.00 | 3.11 |
| 4:47 | 1.56 | 0.80 | 7:09 | 0.00 | 1.58 | 9:27 | 2.04 | 1.94 | 11:53 | 0.00 | 3.11 |
| 4:52 | 1.44 | 0.92 | 7:14 | 0.00 | 1.58 | 9:32 | 3.72 | 2.25 | 11:58 | 0.00 | 3.11 |
| 4:57 | 0.12 | 0.93 | 7:19 | 0.00 | 1.58 | 9:37 | 0.36 | 2.28 | 12:03 | 0.00 | 3.11 |
| 5:02 | 0.24 | 0.95 | 7:24 | 0.00 | 1.58 | 9:42 | 0.36 | 2.31 | 12:08 | 0.00 | 3.11 |
| 5:07 | 0.00 | 0.95 | 7:29 | 0.00 | 1.58 | 9:47 | 0.48 | 2.35 | 12:13 | 0.00 | 3.11 |
| 5:12 | 0.24 | 0.97 | 7:34 | 0.00 | 1.58 | 9:52 | 0.24 | 2.37 | 12:18 | 0.00 | 3.11 |
| 5:17 | 0.36 | 1.00 | 7:39 | 0.00 | 1.58 | 9:57 | 0.00 | 2.37 | 12:23 | 0.00 | 3.11 |
| 5:18 | 0.00 | 1.00 | 7:44 | 0.00 | 1.58 | 10:02 | 0.00 | 2.37 | 12:28 | 0.00 | 3.11 |
| 5:23 | 0.48 | 1.04 | 7:49 | 0.00 | 1.58 | 10:07 | 0.00 | 2.37 | 12:33 | 0.00 | 3.11 |
| 5:28 | 1.32 | 1.15 | 7:54 | 0.12 | 1.59 | 10:12 | 0.36 | 2.40 | 12:38 | 0.00 | 3.11 |
| 5:33 | 0.96 | 1.23 | 7:59 | 0.00 | 1.59 | 10:17 | 1.32 | 2.51 | 12:43 | 0.00 | 3.11 |

**Figure B-3: 400 South and Puerto Drive Precipitation graph from 9/9/14**

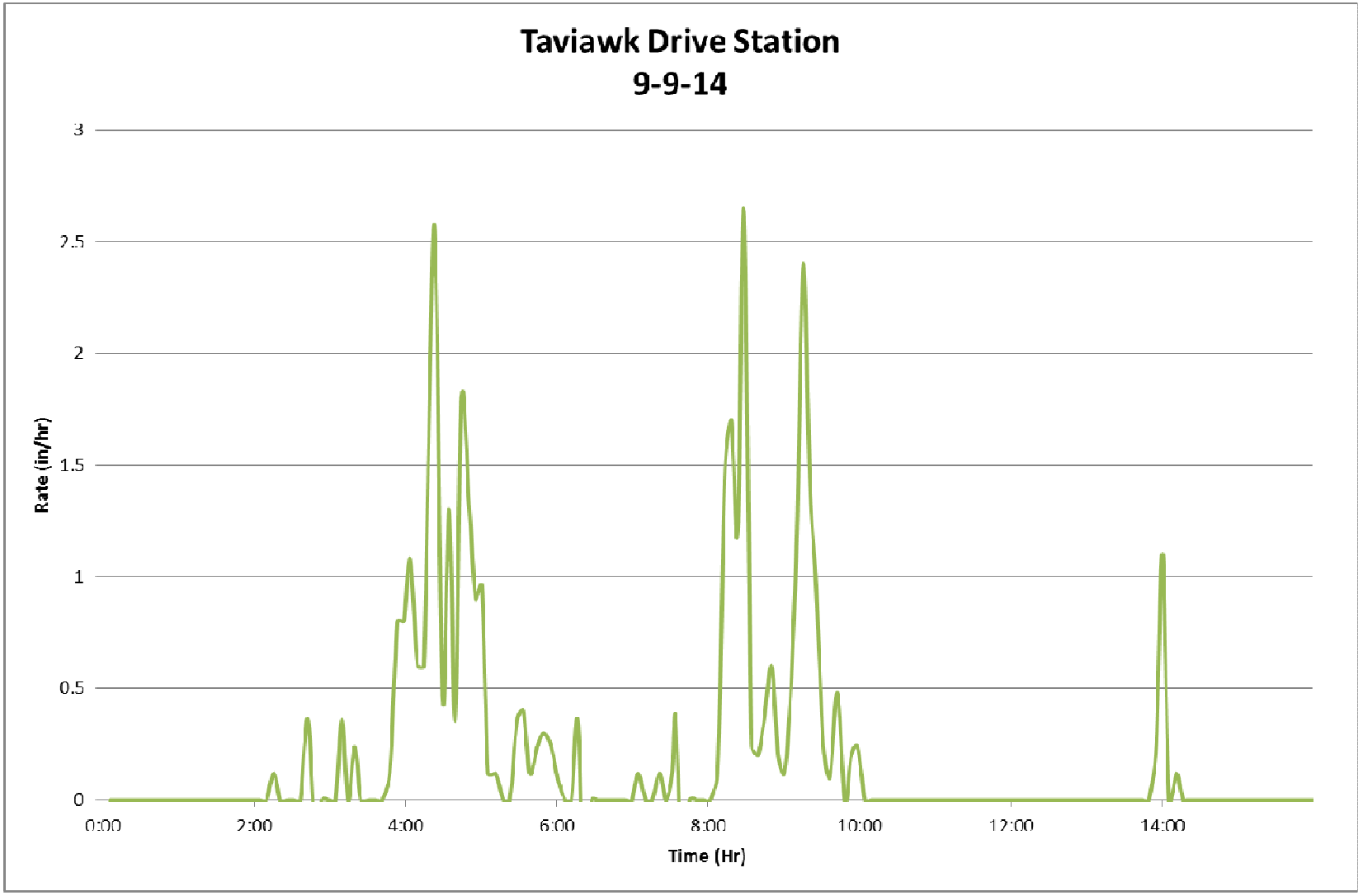


# 9-9-2014 Storm Event

**Table B-3: 9-9-14 Rainfall Data @ Taviawk Drive Station**

| Time | Rate (in/hr) | Total Runoff (in) | Time | Rate (in/hr) | Total Runoff (in) | Time | Rate (in/hr) | Total Runoff (in) | Time | Rate (in/hr) | Total Runoff (in) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 2:11 | 0.12 | 0.01 | 5:30 | 0.40 | 1.52 | 8:46 | 0.60 | 2.41 | 12:01 | 0.00 | 3.09 |
| 2:17 | 0.00 | 0.01 | 5:35 | 0.12 | 1.53 | 8:52 | 0.20 | 2.43 | 12:06 | 0.00 | 3.09 |
| 2:22 | 0.00 | 0.01 | 5:40 | 0.24 | 1.55 | 8:57 | 0.12 | 2.44 | 12:11 | 0.00 | 3.09 |
| 2:28 | 0.00 | 0.01 | 5:46 | 0.30 | 1.58 | 9:02 | 0.48 | 2.48 | 12:16 | 0.00 | 3.09 |
| 2:33 | 0.00 | 0.01 | 5:51 | 0.24 | 1.60 | 9:07 | 1.20 | 2.58 | 12:22 | 0.00 | 3.09 |
| 2:38 | 0.36 | 0.04 | 5:57 | 0.10 | 1.61 | 9:12 | 2.40 | 2.78 | 12:27 | 0.00 | 3.09 |
| 2:44 | 0.00 | 0.02 | 6:02 | 0.00 | 1.61 | 9:17 | 1.44 | 2.90 | 12:33 | 0.00 | 3.09 |
| 2:50 | 0.00 | 0.02 | 6:08 | 0.00 | 1.61 | 9:22 | 0.96 | 2.98 | 12:38 | 0.00 | 3.09 |
| 2:55 | 0.00 | 0.02 | 6:13 | 0.36 | 1.64 | 9:27 | 0.24 | 3.00 | 12:43 | 0.00 | 3.09 |
| 3:01 | 0.00 | 0.02 | 6:18 | -0.36 | 1.61 | 9:33 | 0.10 | 3.01 | 12:48 | 0.00 | 3.09 |
| 3:06 | 0.36 | 0.05 | 6:23 | 0.00 | 1.61 | 9:38 | 0.48 | 3.05 | 12:53 | 0.00 | 3.09 |
| 3:11 | 0.00 | 0.05 | 6:29 | 0.00 | 1.61 | 9:44 | 0.00 | 3.05 | 12:59 | 0.00 | 3.09 |
| 3:16 | 0.24 | 0.07 | 6:34 | 0.00 | 1.61 | 9:50 | 0.20 | 3.07 | 13:04 | 0.00 | 3.09 |
| 3:21 | 0.00 | 0.07 | 6:39 | 0.00 | 1.61 | 9:55 | 0.24 | 3.09 | 13:10 | 0.00 | 3.09 |
| 3:26 | 0.00 | 0.07 | 6:45 | 0.00 | 1.61 | 10:00 | 0.00 | 3.09 | 13:15 | 0.00 | 3.09 |
| 3:32 | 0.00 | 0.07 | 6:50 | 0.00 | 1.61 | 10:06 | 0.00 | 3.09 | 13:20 | 0.00 | 3.09 |
| 3:38 | 0.00 | 0.07 | 6:56 | 0.00 | 1.61 | 10:11 | 0.00 | 3.09 | 13:25 | 0.00 | 3.09 |
| 3:43 | 0.12 | 0.08 | 7:01 | 0.12 | 1.62 | 10:16 | 0.00 | 3.09 | 13:30 | 0.00 | 3.09 |
| 3:49 | 0.80 | 0.16 | 7:06 | 0.00 | 1.62 | 10:21 | 0.00 | 3.09 | 13:36 | 0.00 | 3.09 |
| 3:55 | 0.80 | 0.24 | 7:12 | 0.00 | 1.62 | 10:26 | 0.00 | 3.09 | 13:41 | 0.00 | 3.09 |
| 4:00 | 1.08 | 0.33 | 7:17 | 0.12 | 1.63 | 10:31 | 0.00 | 3.09 | 13:46 | 0.00 | 3.09 |
| 4:05 | 0.60 | 0.38 | 7:23 | 0.00 | 1.63 | 10:37 | 0.00 | 3.09 | 13:51 | 0.24 | 3.11 |
| 4:11 | 0.60 | 0.44 | 7:28 | 0.12 | 1.64 | 10:42 | 0.00 | 3.09 | 13:57 | 1.10 | 3.22 |
| 4:16 | 1.92 | 0.60 | 7:33 | 0.36 | 1.67 | 10:47 | 0.00 | 3.09 | 14:02 | 0.00 | 3.22 |
| 4:21 | 2.52 | 0.81 | 7:36 | -0.60 | 1.64 | 10:53 | 0.00 | 3.09 | 14:07 | 0.12 | 3.23 |
| 4:25 | 0.45 | 0.84 | 7:42 | 0.00 | 1.64 | 10:58 | 0.00 | 3.09 | 14:13 | 0.00 | 3.23 |
| 4:31 | 1.30 | 0.97 | 7:47 | 0.00 | 1.64 | 11:03 | 0.00 | 3.09 | 14:18 | 0.00 | 3.23 |
| 4:36 | 0.36 | 1.00 | 7:53 | 0.00 | 1.64 | 11:09 | 0.00 | 3.09 | 14:21 | 0.00 | 3.23 |
| 4:41 | 1.80 | 1.15 | 7:58 | 0.00 | 1.64 | 11:14 | 0.00 | 3.09 | 14:27 | 0.00 | 3.23 |
| 4:46 | 1.32 | 1.26 | 8:03 | 0.12 | 1.65 | 11:19 | 0.00 | 3.09 | 14:32 | 0.00 | 3.23 |
| 4:52 | 0.90 | 1.35 | 8:09 | 1.50 | 1.80 | 11:24 | 0.00 | 3.09 | 14:38 | 0.00 | 3.23 |
| 4:57 | 0.96 | 1.43 | 8:15 | 1.70 | 1.97 | 11:30 | 0.00 | 3.09 | 14:43 | 0.00 | 3.23 |
| 5:02 | 0.12 | 1.44 | 8:20 | 1.20 | 2.07 | 11:35 | 0.00 | 3.09 | 14:49 | 0.00 | 3.23 |
| 5:07 | 0.12 | 1.45 | 8:25 | 2.64 | 2.29 | 11:40 | 0.00 | 3.09 | 14:54 | 0.00 | 3.23 |
| 5:13 | 0.00 | 1.45 | 8:30 | 0.24 | 2.31 | 11:45 | 0.00 | 3.09 | 14:59 | 0.00 | 3.23 |
| 5:19 | 0.00 | 1.45 | 8:36 | 0.20 | 2.33 | 11:50 | 0.00 | 3.09 | 15:04 | 0.00 | 3.23 |
| 5:24 | 0.36 | 1.48 | 8:41 | 0.36 | 2.36 | 11:55 | 0.00 | 3.09 | 15:09 | 0.00 | 3.23 |

**Figure B-4: 400 South and Puerto Drive Precipitation graph from 9/9/14**



# APPENDIX C
# COST ESTIMATES

**Table 1**
**Conceptual Cost Estimate Unit Cost Summary**
**Ivins Storm Drainage Plan**

| Description | Unit | Size | Ivins City Proposed Unit Cost |
|---|---|---|---|
| **Detention Basins** | | | |
| Property Acquisition | Acre | | $80,000 |
| Property Land Survey | Lump Sum | | $10,000 |
| Excavation and Hauling | Cubic Yard | | $12 |
| Landscaping (Non-irrigated Native) | Square Foot | | $0.30 |
| Landscaping (Irrigated Turfgrass) | Square Foot | | $2.60 |
| Inlet Apron | Lump Sum | | $12,000 |
| Outlet Structure | Lump Sum | | $16,000 |
| Emergency Spillway | Lump Sum | | $5,000 |
| Riprap | Lump Sum | | $20,000 |
| **Storm Drain Pipelines** | | | |
| Permanent Easement Acquisition | Acre | | $40,000 |
| 18-inch RCP | Linear Foot | 18 | $45 |
| 24-inch RCP | Linear Foot | 24 | $60 |
| 27-inch RCP | Linear Foot | 27 | $70 |
| 30-inch RCP | Linear Foot | 30 | $80 |
| 36-inch RCP | Linear Foot | 36 | $100 |
| 42-inch RCP | Linear Foot | 42 | $130 |
| 48-inch RCP | Linear Foot | 48 | $160 |
| 54-inch RCP | Linear Foot | 54 | $230 |
| 60-inch RCP | Linear Foot | 60 | $260 |
| 66-inch RCP | Linear Foot | 66 | $305 |
| 72-inch RCP | Linear Foot | 72 | $350 |
| 78-inch RCP | Linear Foot | 78 | $440 |
| 84-inch RCP | Linear Foot | 84 | $495 |
| 90-inch RCP | Linear Foot | 90 | $550 |
| 96-inch RCP | Linear Foot | 96 | $600 |
| Manhole | Each | | $4,200 |
| Catch Basin | Each | | $3,000 |
| Traffic Control | Linear Foot | | $18 |
| **Storm Drain Culvert Road Crossings for Creeks and Washes** | | | |
| Pipe Culvert | See RCP Storm Drain Costs Above | | |
| 3' X 6' Box Culvert (2-5 feet of cover) | Lump Sum | | $60,000 |
| Headwalls | Lump Sum | | $4,800 |
| Riprap | Lump Sum | | $64,000 |
| Traffic Control | Lump Sum | | $5,300 |
| Asphalt Road Repair | Linear Foot | | (Pipe Diameter [in feet] + 5') * $7 |
| **Channel Construction** | | | |
| Excavation and Hauling | Cubic Yard | | $14 |
| Landscaping (Non-irrigated Native) | Square Yard | | $2 |
| Riprap | Cubic Yard | | $35 |
| **Other** | | | |
| Mobilization/Traffic control | 5% | | 5 Percent of Construction Cost |
| Contingency | 10% | | 10 Percent of Construction Cost |
| Engineering, Legal, and Administration | 10% | | 10 Percent of Construction Cost |

**Table 2**
**Conceptual Cost Estimate - Pipes**
**Ivins Storm Drainage Capital Facility Plan**

| Project Identifier | Pipe Length (ft) | Diameter (in) | Catch Basin / Inlet Box (EA) | Junction Box / Manhole (EA) | Outlet Works (EA) | Asphalt Cost | Subtotal Cost | Mobilization/Traffic control | Construction Cost Subtotal | Contingency (10%) | Engineering, Legal, Admin. (10%) | Priority Level | Priority 1 (Immediate) Estimated Project Cost (includes Contingency, Engineering, Admin, and Legal Fees) | Priority 2 (Future) Estimated Project Cost )Includes Contingency, Engineering, Admin, and Legal Fees |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| P-1 | 1230 | 24 | 4 | 4 | 0 | $ 3,014 | $ 105,614 | $ 5,281 | $ 110,894 | $ 10,561 | $ 10,561 | 1 | $ 132,000 | $ - |
| P-2 | 420 | 48 | 2 | 1 | 0 | $ 26,460 | $ 103,860 | $ 5,193 | $ 109,053 | $ 10,386 | $ 10,386 | 2 | $ - | $ 129,800 |
| P-3 | 90 | 36 | 1 | 0 | 0 | $ 5,040 | $ 17,040 | $ 852 | $ 17,892 | $ 1,704 | $ 1,704 | 1 | $ 21,300 | $ - |
| P-4a | 1090 | 24 | 3 | 3 | 0 | $ 26,705 | $ 113,705 | $ 5,685 | $ 119,390 | $ 11,371 | $ 11,371 | 1 | $ 142,100 | $ - |
| P-4b | 1000 | 24 | 3 | 3 | 0 | $ 24,500 | $ 106,100 | $ 5,305 | $ 111,405 | $ 10,610 | $ 10,610 | 1 | $ 132,600 | $ - |
| P-4c** | 1330 | 24 | 4 | 4 | 0 | $ 32,585 | $ 141,185 | $ 7,059 | $ 148,244 | $ 14,119 | $ 14,119 | 1 | $ 27,900 | $ - |
| P-5 | 200 | 30 | 1 | 0 | 0 | $ 10,500 | $ 29,500 | $ 1,475 | $ 30,975 | $ 2,950 | $ 2,950 | 1 | $ 36,900 | $ - |
| P-6a* | 1340 | 24 | 4 | 4 | 0 | $ 6,566 | $ 115,766 | $ 5,788 | $ 121,554 | $ 11,577 | $ 11,577 | 1 | $ 173,640 | $ - |
| P-6b* | 1930 | 30 | 5 | 6 | 1 | $ 10,133 | $ 220,733 | $ 11,037 | $ 231,769 | $ 22,073 | $ 22,073 | 1 | $ 331,080 | $ - |
| P-7* | 3380 | 30 | 9 | 11 | 0 | $ 88,725 | $ 432,325 | $ 21,616 | $ 453,941 | $ 43,233 | $ 43,233 | 1 | $ 648,480 | $ - |
| P-8a | 580 | 18 | 2 | 1 | 0 | $ 15,834 | $ 52,134 | $ 2,607 | $ 54,741 | $ 5,213 | $ 5,213 | 1 | $ 65,200 | $ - |
| P-8b | 220 | 30 | 1 | 0 | 0 | $ 6,930 | $ 27,530 | $ 1,377 | $ 28,907 | $ 2,753 | $ 2,753 | 1 | $ 34,400 | $ - |
| P-9a | 1330 | 36 | 4 | 4 | 0 | $ 44,688 | $ 206,488 | $ 10,324 | $ 216,812 | $ 20,649 | $ 20,649 | 1 | $ 258,100 | $ - |
| P-9b | 1450 | 24 | 4 | 4 | 0 | $ 7,105 | $ 122,905 | $ 6,145 | $ 129,050 | $ 12,291 | $ 12,291 | 1 | $ 153,600 | $ - |
| P-10 | 1020 | 24 | 3 | 3 | 0 | $ 49,980 | $ 132,780 | $ 6,639 | $ 139,419 | $ 13,278 | $ 13,278 | 2 | $ - | $ 166,000 |
| P-11 | 1290 | 30 | 4 | 4 | 0 | $ 67,725 | $ 199,725 | $ 9,986 | $ 209,711 | $ 19,973 | $ 19,973 | 2 | $ - | $ 249,700 |
| P-12 | 1270 | 24 | 4 | 4 | 0 | $ 62,230 | $ 167,230 | $ 8,362 | $ 175,592 | $ 16,723 | $ 16,723 | 2 | $ - | $ 209,000 |
| P-13 | 630 | 24 | 2 | 2 | 0 | $ 30,870 | $ 83,070 | $ 4,154 | $ 87,224 | $ 8,307 | $ 8,307 | 2 | $ - | $ 103,800 |
| P-14 | 640 | 30 | 2 | 2 | 0 | $ 33,600 | $ 99,200 | $ 4,960 | $ 104,160 | $ 9,920 | $ 9,920 | 2 | $ - | $ 124,000 |
| P-15 | 590 | 24 | 2 | 1 | 0 | $ 28,910 | $ 74,510 | $ 3,726 | $ 78,236 | $ 7,451 | $ 7,451 | 2 | $ - | $ 93,100 |
| P-16 | 670 | 36 | 2 | 2 | 0 | $ 37,520 | $ 118,920 | $ 5,946 | $ 124,866 | $ 11,892 | $ 11,892 | 1 | $ 148,700 | $ - |
| P-17 | 1480 | 30 | 4 | 4 | 0 | $ 77,700 | $ 224,900 | $ 11,245 | $ 236,145 | $ 22,490 | $ 22,490 | 2 | $ - | $ 281,100 |
| P-18 | 770 | 54 | 2 | 2 | 0 | $ 51,205 | $ 242,705 | $ 12,135 | $ 254,840 | $ 24,271 | $ 24,271 | 2 | $ - | $ 303,400 |
| P-19 | 2160 | 24 | 6 | 7 | 0 | $ 105,840 | $ 282,840 | $ 14,142 | $ 296,982 | $ 28,284 | $ 28,284 | 2 | $ - | $ 353,600 |
| P-20 | 1390 | 24 | 4 | 4 | 0 | $ 68,110 | $ 180,310 | $ 9,016 | $ 189,326 | $ 18,031 | $ 18,031 | 2 | $ - | $ 225,400 |
| P-21 | 1110 | 30 | 3 | 3 | 0 | $ 17,483 | $ 127,883 | $ 6,394 | $ 134,277 | $ 12,788 | $ 12,788 | 1 | $ 159,900 | $ - |
| P-22 | 1240 | 24 | 4 | 4 | 0 | $ 60,760 | $ 163,960 | $ 8,198 | $ 172,158 | $ 16,396 | $ 16,396 | 2 | $ - | $ 205,000 |
| | | | | | | | | | | | | **Priority Pipe Subtotal:** | **$ 2,465,900** | **$ 2,443,900** |
| | | | | | | | | | | | | | **Pipe Grand Total** | **$ 4,909,800** |

* Unit Costs were multiplied by 1.2 due to depth of pipe being deep.
** Cost paid for by developer. City is responsible for upsize of pipe only.

**Table 3**
**Conceptual Cost Estimate - Detention Basins**
**Ivins Storm Drainage Capital Facility Plan**

| Project Identifier | Volume (acre-ft) | Footprint (acre) | Excavation and Hauling ($yd^3$) | Landscaping | Inlet Apron | Outlet Structure | Emergency Spillway | Land Acquisition | Contingency (10%) | Engineering, Legal, Admin. (10%) | Priority | Priority 1 (immediate) - Estimated Project Cost (includes Contingency, Engineering, Admin, and Legal Fees) | Priority 2 (Future) - Estimated Project Cost (includes Contingency, Engineering, Admin, and Legal Fees) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DB-1 | 2.7 | 1.35 | $ 68,094 | $ 17,642 | $ 12,000 | $ 16,000 | $ 5,000 | $ 118,000 | $ 23,700 | $ 23,700 | 1 | **$ 284,100** | **$ -** |
| DB-2 | 3.5 | 1.75 | $ 88,270 | $ 22,869 | $ 12,000 | $ 16,000 | $ 5,000 | $ 150,000 | $ 29,400 | $ 29,400 | 1 | **$ 352,900** | **$ -** |
| DB-3 | 4.2 | 2.1 | $ 105,924 | $ 27,443 | $ 24,000 | $ 16,000 | $ 5,000 | $ - | $ 17,800 | $ 17,800 | 2 | **$ -** | **$ 214,000** |
| DB-4 | 3.7 | 1.85 | $ 93,314 | $ 24,176 | $ 12,000 | $ 16,000 | $ 5,000 | $ 158,000 | $ 30,800 | $ 30,800 | 1 | **$ 370,100** | **$ -** |
| DB-5 | 21.8 | 7.266667 | $ 549,796 | $ 94,961 | $ 12,000 | $ 16,000 | $ 5,000 | $ 591,333 | $ 126,900 | $ 126,900 | 1 | **$ 1,522,900** | **$ -** |
| DB-6 | 1.8 | 0.9 | $ 45,396 | $ 11,761 | $ 12,000 | $ 16,000 | $ 5,000 | $ 82,000 | $ 17,200 | $ 17,200 | 2 | **$ -** | **$ 206,600** |
| DB-7 | 0.0 | 0 | $ - | $ - | $ - | $ - | $ 40,000 | $ - | $ 4,000 | $ 4,000 | 1 | **$ 48,000** | **$ -** |
| DB-8* | 1.5 | 0.75 | $ 37,830 | $ 9,801 | $ 12,000 | $ 16,000 | $ 5,000 | $ 70,000 | $ 15,100 | $ 15,100 | 1 | **$ 180,800** | **$ -** |
| | | | | | | | | | | | **Detention Basin Priortiy Subtotal** | **$ 2,758,800** | **$ 420,600** |
| | | | | | | | | | | | **Detention Basin Grand Total** | | **$ 3,179,400** |

* Commercial Development will be required to participate in facility. City responsible for upsize.

**Table 4**
**Conceptual Cost Estimate - Culverts**
**Ivins Storm Drainage Capital Facility Plan**

| Project Identifier | Project Name | Quantity (EA) | Unit Cost | Contingency (10%) | Engineering, Legal, Admin. (10%) | Priority | Priority 1 (immediate) - Estimated Project Cost (includes Contingency, Engineering, Admin, and Legal Fees) | Priority 2 (future) - Estimated Project Cost (includes Contingency, Engineering, Admin, and Legal Fees) |
|---|---|---|---|---|---|---|---|---|
| C-1 | Kwavasa Dr. Culvert | 1 | 95000 | $ 9,500 | $ 9,500 | - | $ - | $ - |
| C-2 | Old Highway 91 Culvert | 1 | 57600 | $ 5,760 | $ 5,760 | 1 | $ 69,120 | $ - |
| | | | | | **Culvert Priority Subtotal:** | | **$ 69,120** | **$ -** |
| | | | | | | **Culvert Grand Total** | | **$ 69,120** |

* Developer responsible for the upsize of the culvert.

**Salt Lake Area Office:**
154 East 14000 South
Draper, Utah 84020
Phone: (801) 495-2224
Fax: (801) 495-2225

**Southern Utah Area Office:**
1664 South Dixie Drive
Suite E102
St. George, Utah 84770
Phone: (435) 656-3200
Fax: (435) 656-2190

**Boise Area Office:**
776 East Riverside Drive
Suite 125
Eagle, Idaho 83616
Phone: (208) 939-9561
Fax: (208) 939-9571



Bowen Collins
& Associates, Inc.
CONSULTING ENGINEERS