SPRINGDALE
Utah
ESTD 1862

# Springdale Storm Water Master Plan

May, 2021

SUNRISE
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SPRINGDALE
Utah

# THE TOWN OF SPRINGDALE STORMWATER MASTER PLAN

## May 2021

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| MAYOR | Stanley J. Smith |
| COUNCIL MEMBER | Randy Aton |
| COUNCIL MEMBER | Suzanne Elger |
| COUNCIL MEMBER | Adrian Player |
| COUNCIL MEMBER | Lisa Zumpft |
| TOWN MANAGER | Rick Wixom |
| TOWN CLERK | Darci Carlson |
| PUBLIC WORKS SUPERINTENDENT | Rob Totten |
| TREASURER | Dawn Brecke |


PREPARED BY:
SUNRISE ENGINEERING

11 North 300 West
Washington, UT 84780
TEL: 435.652.8450
FAX: 435.652.8416


LICENSED PROFESSIONAL ENGINEER
No. 176874
MARVIN J. WILSON
5-25-21
STATE OF UTAH


Marvin Wilson, P.E.
Principal Engineer
State of Utah No. 176874

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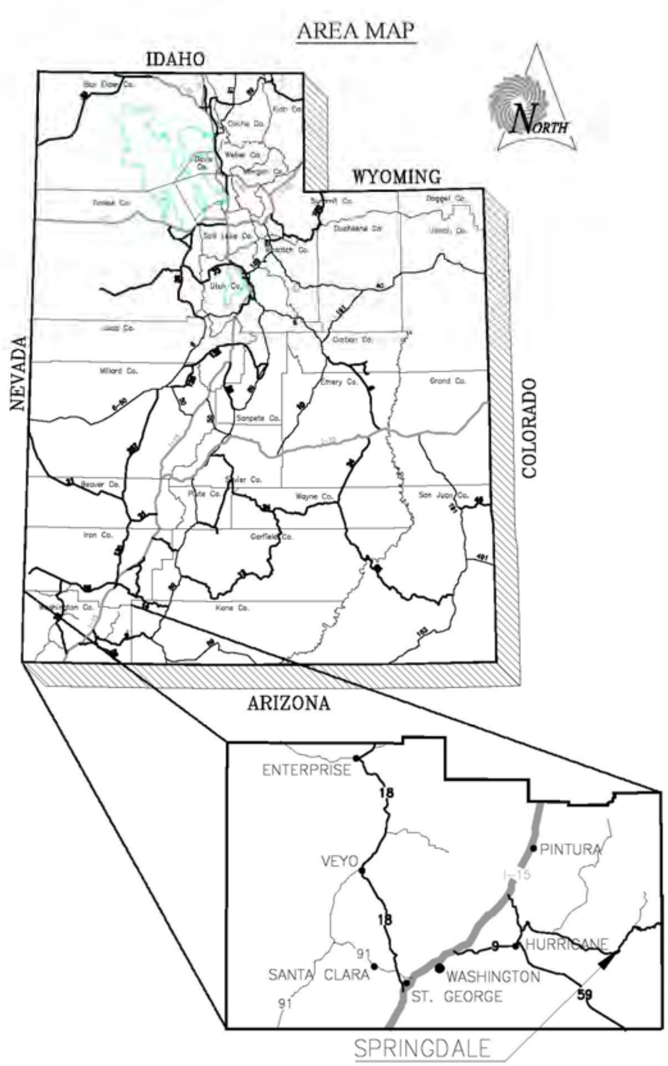
*The Town of Springdale (Town) contracted with Sunrise Engineering, Inc. to prepare this Stormwater Master Plan (Plan) to provide an update of stormwater control facilities, infrastructure in the Town. This plan also provides information regarding current facility deficiencies, recommended improvements, and a list of future prioritized projects.*

*At a glance the Town has both a medium density residential/commercial area with many stormwater drainage improvements and a rural residential area with limited storm drain improvements. The medium density areas improvements consist mainly of curb and gutter that transfers water into pipes. These pipes convey water into washes that enter the Virgin River. The low-density area consists of borrow ditches, culverts, and washes that transfer water to the Virgin River. This Plan provides general requirements for the sizing, maintenance, and configuration of a stormwater management system in the Town of Springdale. This Plan also includes a cost analysis of the system improvements and recommendations for stormwater control ordinances. It is intended that this 2021 Stormwater Master Plan will help the Town of Springdale manage current and future stormwater routing scenarios.*

## I. INTRODUCTION

This Stormwater Master Plan has been prepared for the Town of Springdale, located in Washington County, Utah, east of St. George, Utah along Highway 9 and adjacent to Zion National Park. The Town of Springdale has experienced moderate to high non-residential growth rates for a small town over the past 30 years. As the Town has grown and developed over the years, the construction of homes, multi-residential complexes, hotels, resorts, roads and other improvements typical of developed communities has altered the terrain upon which the community was built and resulted in an increase in stormwater runoff generated by normal storm events. A series of historic ditches, washes, and the old privately owned irrigation system has historically served to collect, route and disperse stormwater generated in the area. Continued development in Springdale and changes in irrigation methods have resulted in general abandonment and discontinued maintenance of the irrigation system. The reconstruction of SR-9 fixed many historical issues from the discontinued irrigation



system. However, there are still questions on how some of the stormwater will be routed in spite of the reconstruction of SR-9 and the additions of curb and gutter throughout the town, questions regarding how stormwater excess is routed through Springdale, and if current improvements have the capacity to handle stormwater runoff appropriately.

Observations and records have shown that the relatively large tributary drainage area and impervious soil types typical of this watershed area produce substantial stormwater runoff volumes, even under the effects of relatively small storms. The potential exists, as natural drainage channels are disrupted by development, for excessive and expensive damage to be caused by flooding. The Town of Springdale and its citizens may potentially spend thousands of dollars after major storm events cleaning up flooded properties, repairing damaged streets, reclaiming damaged stormwater conveyance facilities, removing accumulated debris and mending other damage caused by excessive stormwater runoff.

# II. BASIN DESCRIPTION & DATA COLLECTION

## A. FIELD INVESTIGATION

The Town of Springdale is located just before the south entrance to Zion National Park on SR-9. The Town boundaries include Zion National Park to the north, east and west, and Rockville to the south. The community can be classified as rural and suburban due to varied land uses within the Town; these land uses range from pasture and farmland to moderate density residential housing and commercial use including hotels and resort properties. Development in the Town has had a direct impact on the natural drainage patterns and native ground cover historically found in the area. These changes in ground cover and drainage patterns can increase the potential flooding issues during normal precipitation events.

The overall purpose of the field investigation was to gather data and information regarding existing drainage features, watersheds, basins, sub-basins, soil types, land uses, existing storm drain systems, current problematic areas and other details in the study area. These findings were compared to digitized information and maps obtained from various entities regarding soil types, land uses, and digital elevation models. The gathered information was then used in a hydrologic analysis of the study area to determine the amount of runoff generated by specific precipitation events.

## B. EXISTING DRAINAGE FACILITIES

### Roadway Conveyance

Excess stormwater generated by a given rainfall event typically sheet flows to the curb and gutter system lining the streets in a drainage area and in many cases flow within the curb and gutter system for a distance. Where necessary, valley gutters are located at the street intersections to route stormwater across the intersections. Curb inlet boxes are installed in certain locations within the gutter systems to collect water from the streets and direct it into available storm drain pipes or natural drainage channels. On streets where curb and gutter systems are absent, the centerline profile and shoulder swales often serve as drainage barriers which route excess stormwaters in the direction of highest gradient to the nearest drainage facility or local depression. Due to the steep nature of many of the roadways in the Town, sheet flow can sometimes produce moderately high velocities. Combining these high velocities with large flows.

### Storm Drain Pipe System

Storm drain pipe systems are located in certain portions of Town, and were created for specific drainage regions. These systems include catch basins, cleanout boxes, pipe segments, and outfall structures which discharge stormwaters to the Virgin River. The medium density commercial and residential area in town is composed of curb and gutter with inlet boxes that transfer flow into a stormwater piping system and then to the nearest wash. The low-density rural portion of Springdale is typified by the absence of complete storm drain pipe systems and consist of mainly overland channelized flow to the nearest wash or to the Virgin River. Streets in the rural areas normally lack curb, gutter, inlet boxes and pipe systems. A comprehensive map of the existing storm drain system in the Town of Springdale shows existing improvements with the proposed future improvements. These future improvements are discussed in the System Improvements List presented in Section IV of this Plan.

**Flood Irrigation System**

Remaining portions of a privately owned flood irrigation system exists within the Town of Springdale which historically diverted water from the Virgin River and conveyed it to the fields throughout Town. The system not only served as irrigation purposes but was also effective in collecting and routing stormwater runoff to discharge points along the Virgin River. With the implementation of a regional pressurized irrigation system and with the continued development in the area, portions of the flood irrigation system have been removed or otherwise disrupted making the continued functioning of the system as a stormwater conveyance facility non-functionable. A more detailed discussion of the critical elements of the flood irrigation system will be discussed in Section IV.

**Detention Basin Facilities**

There are currently no regional detention facilities owned and maintained by the Town for the purpose of detaining and releasing controlled amounts of stormwater runoff.

**Drainage Barriers**

There are several drainage barriers that divide and direct stormwater flows generated within the Town of Springdale watershed area. These barriers are the high ridgelines between drainage channels in the watershed. Since there are many drainage channels within the Town, just two major drainage barriers are described below:

- Eastern Ridgeline Barrier: This barrier runs parallel to the Town to the east and extends from the most northern portion of the Town to the most southern. All stormwater runoff generated on the east side of this barrier is routed through the East Fork of the Virgin River and is not a major concern to the Town. Alternatively, all stormwater runoff generated on the west side of this barrier is routed through portions of Town and drains into the North Fork of the Virgin River. The western portion of this barrier produces all drainage channels hereafter described to be on the eastern side of Town.

- Western and Northern Ridgeline Barrier: This barrier runs parallel to the Town and extends from the southern most point of the Town to the most northern, and then extends in toward the east creating a barrier along the northern extent of the Town. Stormwater runoff generated on the northern and western portions of this barrier are routed either through Zion National Park and into the North Fork of the Virgin River or into several washes that travel southwest before draining into the Virgin River to the west of Rockville, neither of which are directly routed through the Town. All stormwater runoff generated on the east side of this barrier is routed through portions of Town and into the North Fork of the Virgin River. This barrier produces all drainage channels hereafter described to be located on the western side of Town.

**Drainage Channels**

There are 12 primary drainage channels that occur naturally within the Town of Springdale watershed area and one main drainage channel. The main drainage channel is the North Fork of the Virgin River. Of the 12 primary channels, 8 are located on the western side of the Virgin River and run from west to east and 4 are located on the eastern side of the Virgin River and run from east to west. The 12 primary channels were determined by the hydrologic analysis and were consistently responsible for directing significant flows during rainfall events. Each drainage channel routes flows from the surrounding mountains and portions of Town and drains into the North Fork of the Virgin River. The drainage channels are described below and are labeled in the diagram given as Figure II.B.1 in Appendix A.

- North Fork of the Virgin River: The Virgin River transects Springdale from north to south. This river is the major drainage feature for Springdale and a significant portion of Washington County. All the subsequent washes drain into the North Fork of the Virgin River. The scope of this plan does not include an analysis of the flow within the North Fork of the Virgin River. This would entail a much larger basin-wide analysis.

- Blacks Canyon Wash: This wash is located next to Lion Boulevard and collects all the runoff from Lion Boulevard and portions of Balanced Rock Road and SR-9. This wash also collects runoff from the entire valley heading west from the end of Lion Boulevard. Large portions of the drainage area are undevelopable, yet the portions which are developable have only been partially developed.

- Springdale Wash: This is located next to Paradise Road. The wash collects all the runoff from Paradise Road and the surrounding streets, including the valley heading west from the end of Paradise Road. Large portions of the developable area have been developed and are drained through this wash.

- Gifford Park Lane Wash: This wash collects all the runoff from Gifford Park Lane, the valley above it, and portions of SR-9. This drainage area is not significantly developed and does not have a large quantity of developable land to the west of SR-9 but does have a significant area of developed land to the east of SR-9 that is drained through this wash.

- Claret Cup Wash: This wash collects and drains runoff from above the LDS church, and portions of Claret Cup and SR-9. The potential for future development in this area to be drained through this wash is minimal.

- Serendipity Lane Wash: This wash collects runoff from Serendipity Lane and the above developments. This wash also collects a significant portion from the valleys above Serendipity Lane. This area is moderately developed and has the potential for future developments to be drained through this wash. There is a significant portion of land currently being used for agricultural purposes along both sides of SR-9 that could be developed and drained by this wash.

- Valley View Drive Wash: This wash collects runoff from Valley View Drive and Kinesava Drive. This area is moderately developed and has the potential for several other housing units to be drained through this wash along both the east and west side of SR-9.

- East Anasazi Wash: This wash and the West Anasazi Wash are the main washes collecting and routing the stormwater from Plateau and the valleys to the northwest. This area is moderately developed and has the potential for significant development.

- West Anasazi Wash: Similar to East Anasazi Wash, the area is moderately developed and has the potential for large future developments to be drained by this wash.

- North Fork Drive Wash: The discharging of this wash into the Virgin River takes place below the southern most point along North Fork Drive. Compared to the size of the overall drainage area of this wash, a very small portion is developable. A smaller number of housing units are located within the drainage area for this wash and a few more could be located in this drainage area in the future. There is however, a portion of land above the wash that could have the potential for future development depending on access and slope requirements. This area is located to the north and the east of the North Fork Road.

- Canyon Cove Circle Wash: This wash drains stormwater from portions of Canyon Springs Drive and Canyon Cove Circle. Several housing units currently exist within the drainage area of this wash and the potential exists for several other housing units to be located within the drainage area of this wash. On the other hand, the developable area within the drainage area of this wash is meager compared to the overall size of the drainage area.

- Canyon Springs Drive Wash: This wash drains stormwater for a small portion of Canyon Springs Drive. The portion drained is very insignificant compared to the overall drainage area for this wash and has minimal potential for developments.

- Desert Pearl Inn Wash: This wash is located across the river from the Desert Pearl Inn and currently does not drain stormwater for any developments. The drainage area for this wash has very minimal potential for developable land, and all the developable land in the area is close enough to the Virgin River that stormwater could be routed directly to the Virgin River, avoiding the need to be drained through this wash. Although this is the case for most of the developable area in this drainage area, there is still the possibility of draining a few housing units ultimately through the wash with insignificant impact to the overall peak flow.

## C. WATERSHED INFORMATION

Work performed during the data collection and field investigation phase of this study included a detailed review of how excess stormwater within the Town of Springdale watershed was routed to the primary drainage channels and pipe systems previously described, and ultimately to the Virgin River. The direction of stormwater flow was established for local developments and existing stormwater conveyance facilities were reviewed to understand how they route stormwater to the major drainage channels. After these patterns were determined, watershed drainage basins and sub-basins were delineated.

A drainage basin is a portion of a greater watershed area that has specific, well-defined boundaries and produces runoff at a downstream point location. A sub-basin is an area with a drainage basin that is characterized by similar drainage features and typically similar land use. Dividing larger watershed areas into individual drainage basins and sub-basins allows more detailed and accurate analyses of the individual areas. These individual analyses can then be combined to generate data for the large basins and the watershed as a whole. This process was followed for this Plan.

The Town of Springdale is divided into two distinct drainage basins by the drainage barriers discussed in the previous section. These drainage basins include the Eastern Basin and the Western Basin; the name of each of these basins is derived from the primary location of the channels to which each of them drain, either from the east or from the west into the Virgin River. Figure II.C.1 and Figure II.C.2 in Appendix A illustrate the drainage basins and sub-basins. The numbering system used in these figures was based on the order in which they drain into the Virgin River, 1 being the most upstream basin and so forth.

## D. SOIL TYPE INFORMATION

The soil type within a watershed area has a significant impact on how much excess stormwater is available for runoff because the soil type determines the precipitation infiltration rate. This infiltration rate is the rate at which water moves from the ground surface into subsurface soil layers. If the infiltration rate is very high, stormwater runoff generated by precipitation events is lower because a greater volume of moisture is absorbed by the soil. Conversely, if the infiltration rate is low, higher volumes of runoff are generated because minimal absorption occurs in the subsurface soil layers. The Soil Conservation Service (SCS) has studied soil types throughout the United States and has grouped soils according to their type and infiltration rates. These groups are described in the list below:

Group A: These soils have a high infiltration rate. They are chiefly deep, well drained sands or gravel, deep loess, or aggregated silts. *They have low runoff potential.*

Group B: These soils have a moderate infiltration rate when thoroughly wet. They are moderately deep and well drained and of moderately fine to moderately coarse texture. Examples are shallow loess and sandy loam.

Group C: These soils have a slow infiltration rate when wet. They are soils with a layer that impedes downward movement of water and typically have moderately fine to fine texture. Examples are clay loams or shallow sandy loams. These soils are typically low in organic content and high in clay content.

Group D: These soils have a very slow infiltration rate. They are chiefly clay soils with high swelling potential. A high water table is often permanent. Clay pan is often found at or near the surface. A shallow layer of soil may cover a nearly impervious material. Examples include heavy plastic clays and certain saline soils, exposed bedrock formation such as sandstone, granite, etc. *They have high runoff potential.*

The SCS has performed a study of the soils in the Town of Springdale and the surrounding area. This study reveals that the soil types are primarily of groups B and D. Soil type maps and descriptions of the study area were obtained from the SCS and were used in the watershed analysis described by this Plan. A map of the SCS soil types in the Town of Springdale watershed area is given as Figure II.D.1 in Appendix A.

## E. LAND USE PATTERNS

The type of land use in a given watershed area is a factor that significantly affects the magnitude of stormwater flow and runoff volume generated by precipitation events over the watershed area. Land uses that have relatively higher percentages of impervious surfaces such as parking lots, shopping areas, storage yards and high density residential housing tracts generate more stormwater runoff than areas with lower percentages of impervious surfaces such as parks and grasslands. Examination of current aerial photographs, field investigations, review of the Town of Springdale's zoning map, and land use survey data obtained from the Environmental Protection Agency (EPA) allowed land use trends within the Town to be identified for the purposes of this study. The Town has a moderate variety of developed land uses that include:

- <u>Light Commercial:</u> This includes small shops, hotels and other businesses.
- <u>Medium Density Residential:</u> This use includes housing on 1/2 to 1 acre lots.
- <u>Low Density Residential:</u> This use includes housing on 1 acre or greater.
- <u>Orchards, Groves and Other Similar Land Types:</u> This use includes some agricultural land and specific uses such as orchards and groves.
- <u>Brush Terrain:</u> This area includes regions of undeveloped natural brush terrain.
- <u>Evergreen Forest Land:</u> This area includes regions of undeveloped forested terrain.

Springdale is currently experiencing moderate municipal growth with construction of a few developments planned in the Town. Development in the Town has been governed by and has generally followed guidelines established by adopted zoning ordinances. It was assumed, for the purposes of this study and for predicting future land use patterns within the Town of Springdale, that development and land use will generally follow the current Springdale Zoning Map. The current and future land use maps are illustrated as Figure II.E.1 and Figure II.E.2 in Appendix A.

## F. HISTORY OF FLOODING & COMPLAINTS

The data collection and field investigation process completed for this study included a review of locations within the Town of Springdale where flooding, due to precipitation events, has been a problem. A summary of the more significant chronic flooding areas are given in the bulleted list as follows:

- Water Washing out across SR-9: Runoff during large precipitation events flow sediment down SR-9. A portion of the abandoned irrigation ditch collects runoff from the surrounding hills and the stormwater exits the ditch just north of the Montclair Inn and causes flooding on the road. Elm Street produces sediment runoff that flows down SR-9 into the storm drain system. Stormwater sheet flows over SR-9 and washes out the median between the street and trail onto the trail.
- Locations of washed out borrow ditches that cause ruts through driveways and

bring sediment onto the pavement. Locations include Foothill Ln, the area South of Apple Ln where curb and gutter ends, north of Valley View Dr where curb and gutter ends.

- Locations of Ponding: Runoff during small to large storm events cause ponding just to the east of Park Zion on SR-9.

- Culvert Discharge to Field: There are many examples in the Town where stormwater is collected on the western side of SR-9 and routed through a culvert which then discharges into a field rather than being routed directly to the Virgin River. It is assumed that this practice is acceptable since it has been going on for some time now and hasn't produced any major problems. It should be noted that if the discharge field is developed, the developer should be held responsible for routing the stormwater through an underground pipe system or constructing an open channel conveyance facility and providing legal drainage easement for the drainage to be maintained as such per Town standards. If a single house or business is built where the drainage occurs into the field, then the owner should be responsible for passing said drainage beyond the developed area. These discharge fields specifically include but not necessarily limited to: the field to the north of the orchard on the south end of Town, the field across SR-9 from Dixie Lane, the field between Serendipity Lane and Wanda Lane, and the multiple fields to the southwest of River Park.

# III. HYDROLOGICAL ANALYSIS

## A. INTRODUCTION

After the field investigation and data collection process outlined in Section II of this Plan was performed, a hydrologic analysis of the drainage basins which contribute runoff flow to the Springdale study area was completed. The WMS® software package was used to determine the basin characteristics required by HEC-HMS as inputs. HEC-HMS, a system developed by the Army Corps of Engineers, was used in this analysis to determine peak and total volume flows generated in the drainage basins. The main purpose of this analysis is to provide reference information for future analyses, basic data for future designs, and to ensure that no current systems within the Town of Springdale are largely undersized or under designed.

Certain assumptions and modeling parameters that mathematically describe precipitation and runoff characteristics of the study area were required for development of the computer model. These parameters include:

Method of Analysis
Basin Delineation
Rainfall Data
Design Storm
Soil Type and Land Use Characteristics
Lag Time

A discussion of these input parameters and the process of creating the hydrologic model is given in Section B below. Results generated by the computer model are discussed in Section C.

## B. HYDROLOGICAL MODEL

**Method of Analysis**

Numerous methods have been developed for performing hydrologic analyses for given watersheds. Each of the methods has its strengths and weaknesses; therefore, particular methods are better suited to specific watershed characteristics and configurations. The method chosen to analyze the Town of Springdale watershed was the SCS Unit Hydrograph Method. This method, developed by the Soil Conservation Service, is best suited for urban or rural conditions with drainage basin areas ranging from one to 2,000 acres. Data required for input includes rainfall intensities, predominant soil types, land use patterns, runoff times of concentration ($T_c$) for individual basins and runoff curve numbers (CN) for individual basins. Output results are runoff hydrographs from which peak flows and volumes can be determined.

In the Unit Hydrograph Method, input data is used to create a direct hydrograph that results from one inch of excess rainfall uniformly distributed over the watershed area for a specific duration storm event. After the unit hydrograph is created, it can be used to generate flood hydrographs for design storms (i.e. 10-year 3-hour, 100-year 3-hour, etc.) based on the theory that individual hydrographs resulting from successive increments of rainfall excess that occur throughout a storm period will be proportional in discharge throughout their length. The WMS® and HEC-HMS software package run the SCS method to generate stormwater discharge hydrographs based on the required input data. Hence, this package was appropriately suited for analysis of the Town of Springdale watershed.

**Sub-basin Delineation**

In order to effectively model precipitation and runoff scenarios for the Town of Springdale watershed, the study area was divided into two major drainage basins: the eastern and western basins. The total number of sub-basins was 37 within both basins.

Figure II.C.1 through Figure II.C.2 in Appendix A illustrate the basin and sub-basin delineations. These sub-basins were automatically delineated from a digital elevation model (DEM) imported into WMS from the Utah AGRC website.

**Rainfall Data**

Rainfall data necessary for input into the computer model was taken from the National Oceanic Atmospheric Administration (NOAA) website ATLAS 14. The table provides information regarding design storm depth-duration-frequency (DDF) of rainfall depths as given in Table III.B.1 in Appendix B. The precipitation data given in a DDF table can be used to create a DDF curve which is a relationship between the depth, duration, and frequency or return period of a given storm event. This, in turn, can be used to produce a storm temporal distribution. This distribution is a relationship between the percentage of rain produced given the amount of time that has elapsed. These distributions are related to the design storm duration and the distribution used in this study can be found in Table III.B.2 in Appendix B.

**Design Storm**

The design storm for a hydrologic analysis is normally chosen based upon data observations that reveal the type of precipitation event that produces the highest peak flows and volumes for a given watershed under realistic rainfall event conditions. In the western United States and especially arid areas, storms that generally produce the highest levels of runoff are thunderstorms. Historically, the rainfall event frequency used to size storm drain conveyance facilities in Utah has been either the 5-year or 10-year 3-hour storm while the 100-year 3-hour storm has generally been used to size detention facilities.

It has been concluded for this Plan that runoff conveyance facilities for the Town of Springdale should be designed for the 10-year 3-hour storm and detention facilities to be designed for the 100-year 3-hour storm. This standard is consistent with that used in most areas of Utah and is the same as the design criteria for storm drain systems in St. George City. Detention basin facilities and calculations would be based on results produced by the 100-year 3-hour storm, but since no detention facilities exist within the Town of Springdale, this criteria was not used.

**Soil Type and Land Use Characteristics**

One factor that significantly affects the amount of runoff generated by a particular watershed is the soil type within the watershed. Different soils have different infiltration rates, or rates at which water can move through the surface to subsurface layers and thus be held from flowing off the watershed via surface drainage. If the infiltration rate is high, the runoff generated from storms is decreased. If the infiltration rate is comparatively low, precipitation will flow off the watershed rather than being absorbed.

Another important factor that affects the amount of runoff generated by a watershed is land use. Developed areas have a higher percentage of impervious surfaces like streets, driveways, parking lots and roofs while undeveloped areas are typified by pervious surfaces and plant features that are more efficient at absorbing precipitation, preventing it from leaving the watershed as runoff. The results are that higher rates are expected with increased development than are typically observed from a watershed in its natural condition.

The effect of soil types and land uses on watershed runoff flows and volumes is accounted for within the SCS Unit Hydrograph method for hydrologic analysis by the runoff curve number (CN). The Soil Conservation Service has calculated CN values for each soil group based on particular land uses. Representative curve numbers were calculated by the computer model according to soil maps and land use maps imported into the model under build out conditions. These soil type maps and land use maps are given in Figure II.D.1 and Figure II.E.1 and Figure II.E.2 in Appendix A. Each sub-basin was assigned by the model a composite CN value based on a weighted average of the different soil and land use types located within each basin. Curve number values assigned to each of the basins are included in tabular form in Table III.B.3 in Appendix B.

**Time of Concentration**

The final input parameter required for the hydrologic model is the lag time ($T_l$) which is generally defined as the time between the center of mass of effective rainfall and the inflection point on the recession (falling limb) of the direct runoff hydrograph. This is often related to the time of concentration which is defined as the time that must elapse before the entire basin area is contributing runoff at the outflow point of the basin. This parameter helps to define the shape and peak of the resulting hydrographs from rainfall events. Factors that determine the lag time are the length of overland flow (*L*) which is the maximum distance that water must travel from the upper extremity of the basin to the outflow point, the curve number (*CN*) which accounts for the soil infiltration capacity, and the slope (*S*) which is the average surface slope within the basin.

Of the various methods used to calculate the lag time, the SCS lag method is well suited for the hydrologic conditions characteristic of the Town of Springdale watershed area. The SCS lag equation was developed from observations of agricultural watersheds where overland flow paths were poorly defined and channel flow was absent, but the method has been adapted to small urban watersheds less than 2,000 acres in area and performs reasonably well for areas that are completely paved. Hence, the method can be applied to each of the basins within the Town of Springdale study area. The SCS lag equation is expressed as follows:

$$T_l = \frac{L^{0.8}\left(\left[\frac{1000}{CN} - 10\right] + 1\right)^{0.7}}{1900 * \sqrt{S}}$$

where $T_l$ is the lag time in hours, *L* is the basin hydraulic length in feet, *CN* is the SCS runoff curve number and *S* is the average surface slope of the basin in percentage.

Evaluation of the lag time equation reveals that as the length of the basin decreases and the SCS runoff curve number and slope increase, the calculated lag time decreases. It is important to note that the time of concentration and the lag time has a significant effect on the size and timing of the peak flow from a watershed basin;

therefore, care must be taken to accurately calculate this parameter. The lag time was calculated in WMS® for each basin within the study area. Table III.B.3 in Appendix B includes a column that lists the calculated lag times for each sub-basin.

## C. HYDROLOGICAL MODEL RESULTS

Information regarding sub-basins, rainfall data, design storms, current and future land uses, soil types and times of concentration were compiled using WMS®. Following the compilation of the watershed and rainfall information an analysis using HEC-HMS was run which generated runoff hydrographs for each sub-basin in the watershed area. The runoff hydrographs provided values on peak flows, elapsed time to peak runoff and total volumes for each sub-basin. Peak flows and volumes resulting from the 10-year and the 100- year 3-hour storm events under existing and predicted future development conditions in the Town of Springdale are summarized in Table III.B.3 through Table III.B.4 in Appendix B. The model results were checked for accuracy using the rational method. Similar results were obtained using this method. As a result, the computer-generated values are considered to be within the accepted industry standards.

Figure III.C.1 in Appendix A is the drainage flow chart for each of the sub-basins as they are discharged into the Virgin River in series.

# IV. SYSTEM ANALYSIS

## A. INTRODUCTION

After the hydrologic analysis described in Section III of this Plan was completed, a general overall evaluation of existing drainage conditions and facilities in the Town of Springdale was performed to determine the adequacy of existing storm drain conveyance and routing facilities. This evaluation included hydraulic analyses of existing drainage features such as roadways, storm drainpipe systems, drainage swales, etc. The results of this analysis were used to reveal locations of flooding potential, to indicate where additional storm drain systems, improvements, or repairs are needed, and to provide insight on the prioritization of future projects and improvements. This evaluation involved studying the hydrologic data and discussion from Section III and a confirmation of the compiled data from the field investigation.

The discussion presented in this section includes an analysis of existing storm drain facilities, recommendations for repairs to the existing system, and proposed construction of additional storm drain facilities. A brief and general description of the existing storm drain facilities is given in Subsection B. Subsection C presents the recommended improvements and changes to the Springdale Town stormwater system which are needed to alleviate present problems.

## B. EXISTING FACILITIES

Primary stormwater conveyance facilities existing in the Town of Springdale include the roadway systems, swales, storm drainpipe systems, culverts and natural drainage channels. A brief discussion of the role and conveyance capabilities of each is given in the following highlighted subsections. This subsection is meant to be informative and provide details regarding the design methods used to determine system improvements.

**Roadway Conveyance**

After precipitation contacts the surface, excess stormwater begins to flow in the direction of highest gradient to concentration points. These concentration points are often a roadway with its defined edges being formed by a curb and gutter system or swales. The stormwater conveyance capacity of a given roadway is governed primarily by its cross-sectional shape as determined by the curb and gutter configuration and the cross slope of the roadway. Like any other conveyance channel, the longitudinal slope and surface roughness also strongly influences the capacity. If it is assumed that a road way is lined on both sides with high back curb, the cross slope of the roadway is 2.0% and the average Manning's roughness (n) of the roadway is 0.014 (a very conservative value), the conveyance capacity of the roadway can be closely approximated by the equation:

$$Q_{capacity} \approx 25.18\sqrt{S}$$

where Q *capacity* is the conveyance capacity of the roadway in cubic feet per second and S is the longitudinal slope of the roadway in percent. This equation holds true for all roadway right-of-way widths. For those streets that are lined with only one side of curb and gutter this capacity is simply cut in half. A specific inventory of all streets typified by curb and gutter is not listed in this section due to the fact that specific listing of such facilities is not necessary. Many of the streets in the Town of Springdale roadway network are not characterized by the idealized cross section used to develop the street flow capacity equation given above. Many of the streets in the low density portions of Springdale have no curbs at all and depend on swales to convey all stormwater flows from the immediate surrounding area. For these cross sections it can be expected that the flow capacity is significantly lower. Capacities of these swales is explained in the next subsection.

**Swales**

Similar to the roadway conveyance systems in the Town, a specific inventory of all the swales within the Town will not be listed here, but any specific problem areas will be discussed later on in this section. The stormwater conveyance capacity of a swale is governed primarily by its cross-sectional shape. Like any other conveyance channel, the longitudinal slope and surface roughness also strongly influences the capacity. Assuming these governing factors, the swale capacity can be approximated by Manning's equation:

$$Q = \frac{1.486}{n} AR^{2/3} S^{1/2}$$

A defines the area of the wash cross section and R defines the wetted perimeter of the wash. Since the majority of the swales in the Town of Springdale are somewhat vegetated the n-value used for this analysis was a conservative value of 0.03. Also, to simplify the analysis process, all the swales in the Town were assumed to be trapezoidal shaped, with a 6” bottom width and a depth of 6” with 1:1 side slopes. With these assumptions the above equation was simplified to the following equation:

$$Q = 10.1 * S^{1/2}$$

If the street has swales on both sides then the capacity is doubled since this equation is for a single swale. Several of the streets in the Town were analyzed to determine the required capacity to route both the 10-year and 100-year stormwater events using the swales, curb and gutter, and a combination of the two. It was determined that each of these streets was capable of conveying the 10-year and routing the 100-year anticipated peak flows and thus no required improvements are necessary. However, the facilities responsible for discharging those flows into the local pipe systems or washes were not analyzed as part of this master plan and could be a possible bottleneck for stormwater flows. The analyzed streets and the calculated capacities and peak flow calculations have been included in Appendix C.

**Storm Drainpipe Systems**

Storm drainpipe systems installed in certain areas of the Town are, for the most part, complete and functional systems. These systems generally include catch basins, cleanout boxes, pipe segments, and outfall structures. By all appearances, these systems are functioning as designed and are effectively conveying storm water out of the nearby streets and developed areas.

These major storm drain systems are highlighted and briefly described in the bulleted list.

- Holiday Inn System: The system has inlet boxes along SR-9 close to the south entrance to the Zion Park Inn. These inlets collect stormwater from both sides of SR-9 to the north 700 feet and to the south 650 feet. The stormwater entering these inlet boxes combine with stormwater entering the pipe system used by the hotel for their drainage and is discharged into the Virgin River.

- Moenave Subdivision System: The system has inlets in the Moenave subdivision and Best Western that direct water into a pipe system that borders Blondies Diner. The system also has inlet grates along SR-9 and are located approximately 200 feet to the south west of Elm St. These inlets collect stormwater from both sides of SR-9 all the way from Lion Boulevard to Paradise Road. The stormwater entering these inlet grates is discharged into the Virgin River.

- Hummingbird Lane System: The system collects stormwater from Balanced Rock Road and the parking lot adjacent to Balanced Rock Road and SR-9. The system has inlet grates located where SR-9 intersects Hummingbird Lane and along Hummingbird Lane. These inlets collect stormwater from SR-9 to the north 900 feet and to the south 300 feet, including all of Hummingbird Lane. The stormwater entering the system is discharged into the Virgin River.

- Cable Mountain System: The system collects stormwater from portions along SR-9, several washes crossing SR-9 and the area around Cable Mountain. The stormwater is discharged into the Virgin River.

- Juniper Ln. System: The system collects stormwater from portions of SR-9 and Juniper Ln. The stormwater is collected into a catch basin that percolates into the ground. When the basin limit is exceeded the water overflows into the downstream field.

Excess stormwater routed into these systems generally enters the storm drainpipe system through catch basins and inlet boxes. Covers and grates for these inlet boxes have many different sizes and configurations which affect the amount of stormwater that can be captured by these boxes. If the actual grate is smaller or becomes choked with debris or is otherwise clogged, the capture capacity is reduced. Limited capacity at a grate may cause localized flooding and may also cause flooding at down-stream grate locations due to the reduced amount of water being captured at upstream locations. Future storm drain system designs and development requirements should respect these facts.

**Culverts**

The majority of the conveyance facilities in the low density portions of Springdale are comprised of natural drainage channels along the edge of the road. With this being the case, several culverts are located throughout the Town to convey stormwater under roadways or other such embankments.

The shapes of these culverts may vary, but most are understood to be circular. Culvert construction materials also vary. Many are made from steel, concrete, and plastics. Culvert inlet and outlet configurations also vary. All these factors, including the size of the culvert, contribute to the conveyance capacity.

## C. SYSTEM IMPROVEMENTS

The runoff results of the hydrologic analysis (summarized in Table III.B.3 and Table III.B.4) were compared to the flow capacities of the existing improvements near the location of the sub-basin outlets. This comparison was the basis for the improvement recommendations provided in this section.

In general, the runoff generated in the existing drainage sub-basin which drains the majority of the developed portion of the Town does not exceeds the capacity of the existing downstream improvements.

A map of the recommended improvements has been included as Figure IV.C.2 in Appendix A.

**Recommended Improvements:** Improvement are assigned numbers. These improvements are labeled by the associated number below in Appendix A Figure's IV.C.1 – IV.C.9.

<u>East Springdale Drainage Channel</u>

1. Construct curb and gutter along Foothill Drive to tie into existing curb and gutter at the intersection of Winderland Lane. Current conditions cause rutting alongside the roadway and push sediment onto the roads.

2. Install curb and gutter along SR-9 from the end of existing curb and gutter south of the LDS church to Quail Ridge Drive. High flows generated by the church as well as the surrounding streets have historically caused the soil at the end of the curb and gutter to be washed out and eroded away, causing a safety hazard and the curb and gutter to be undercut.

3. Construct a conveyance facility to route storm water from the irrigation ditch just south of Claret Cup. This irrigation ditch is dilapidated and not under Town control; however, the irrigation ditch collects water from the surrounding area and discharges it near SR-9. The newly constructed conveyance facility will collect this runoff and pipe it to the Virgin River. Additionally, the downspout overflow causes runoff and sediment buildup on SR-9. Construct a detention basin or hydromarine separator south of Claret Cup to prevent sedimented water from entering the road. We would recommend a detention basin if the site has sufficient area; however, if limited area exists we would recommend a hydromarine separator. The separator is more compact and can fit on small sites but it also requires more regular maintenance. Portions of the ditch may deteriorate and cause additional flooding problems in the future. Additional solutions will need to be looked at if the irrigation deterioration causes problems to SR-9.

4. Improve the swale just north of the Majestic View Lodge that connects the conveyance facilities in front of the Majestic View Lodge to the Valley View Drive Wash. (2176 Zion Park Blvd.) The swale can be improved with either curb and gutter or a rock lined ditch. The curb in gutter performs better as far as maintenance is concerned; however, a rock lined ditch may have the aesthetics that the town would like to preserve.

5. Construct a hydromarine separator on Elm Street on the back side of the sidewalk. The separator will prevent sediment from entering SR-9. The hydromarine separator is a catch basin that helps settles the particles of incoming flow and discharges cleaner water. The hydromarine has a sump that will need to be cleaned.

6. Construction of a natural planted transition between SR-9 and the multipurpose paved trail. Many sections of SR-9 are bordered by a multipurpose paved trail. A small transition section that separates SR-9 and the trail is currently filled with road base. During storm events sheet flow from SR-9 causes sediment to be pushed onto the multipurpose trail. Remove the road base and add proper soil or cobble landscaping with natural vegetation. This problem could also be solved by adding curb and gutter on the edge of the road. The curb and gutter is a better option for maintenance and longevity; however, it does not have the same aesthetics that the planted transition would have.

7. Construct a gravel conveyance ditch to drain puddled runoff to the west of the Zion Park parking lot entrance. The conveyance ditch should span from the back side of the curb and gutter and enter the existing culvert to the East.

8. Several smaller washes discharge into a section of privately owned irrigation ditch from Claret Cup to Quail Ridge Road and eventually flow into a storm drain inlet across from River Park just south of Quail Ridge Road. Private owners should maintain this ditch. If the ditch is not maintained then there is potential for runoff and sediment to get on SR-9.

9. There is the possibility for the Claret Cup Wash to overflow its banks at SR-9 without proper maintenance. The SR-9 culvert is under the jurisdiction of UDOT and should be maintained by UDOT. Upstream and downstream of SR-9 the culvert is privately owned. It is recommended that private owners maintain the wash. All culverts crossing SR-9 are under the jurisdiction of UDOT and should be maintained by UDOT.

10. Double chip seal the maintenance shed road and add culverts along low areas. This will prevent the road from washing out during storm events.

11. There are several locations throughout the Town where stormwater discharges from stormwater facilities or existing washes into open fields. Since this practice has been going on for quite some time with seemingly insignificant problems, it is recommended that no effort be made to route the stormwater through these fields to a more appropriate discharge point. The Town has an ordinance requiring that the developer construct a stormwater routing system to properly discharge it to an existing facility, natural wash, or the Virgin River. The routing system within the development should be

properly engineered to ensure the capacity of the conveyance facility is adequate for the existing flows into the field. The routing system should also be an acceptable method for stormwater conveyance, i.e. open channel, underground piping, etc.

12. Construct an inverted crown on Big Springs Rd. to convey water away from residents. The outflow water is routed toward commercial property. The commercial property has existing storm drain. It is recommended that the Town work with the commercial property and work out an agreement that allows the Town to route the Big Springs Rd. flow into the commercial storm drain infrastructure.

13. Construct curb and gutter along Hummingbird Rd. The curb and gutter will better help to direct runoff into the Virgin River.

14. Construct Curb and Gutter on Balanced Rock Rd. Current storm water flows undercut Balanced Rock Road. Curb and gutter should be installed to redirect flow into the curb and gutter and eventually into the Hummingbird Rd. storm network.

15. Construct curb and gutter or a rock lined ditch on Lion Boulevard. Construction of curb and gutter will help maintain road from stormwater undercutting the side of the road. Curb and gutter would be the best solution for maintenance reasons; however, a rock lined ditch would work well if the town would prefer different aesthetics. Install curb inlets or catch basins prior to Winderland Ln. to route storm water to Blacks Canyon Wash through a 24” pipe.

## D. NATURAL DRAINAGE CHANNEL INFRASTRUCTURE

Due to the critical nature of conveying and routing stormwater runoff of the many natural drainage channels located throughout the Town of Springdale, it is recommended that the Town take proper action to preserve and protect them for this purpose. It is recommended that the Town adopt an ordinance to preserve these existing channels as drainage rights-of-way to be maintained and preserved as part of the stormwater facilities.

It is not economical for the Town to construct an infrastructure of underground stormwater conveyance trunk lines as long as these natural channels remain unobstructed and in working condition. With this intended use of the natural drainage channels, it also recommended that future developments in the Town shall not obstruct these channels. In the event that this is not possible, for one reason or another, then it should be the responsibility of the developer to reconstruct an open channel or an underground piping system to convey the flows through the development. In turn, future developments within the Town should be allowed to discharge stormwater produced in the development into these natural drainage channels at the same natural rate prior to development. Doing so will most likely require construction of a detention facility. The developer will be responsible for determining the historical discharge rate produced by the land being developed and the proper capacity of the detention facility. Such determination by developer should be subject to review and acceptance by the Town.

In order to prevent excessive pollutants from entering these natural channels, it is also recommended that stormwater be partially treated before being discharged into the channels. Possible treatment could include the removal of suspended solids, trash, debris, and oil. See Subsection F for further information regarding water quality management recommendations improvements.

## E. MAINTENANCE AND MISCELLANEOUS IMPROVEMENTS

There are several improvements and practices that will enhance the ability for the Town of Springdale to manage stormwater runoff. These improvements include both structural and non-structural items. They are:

- <u>Pave or Chip Seal Unimproved Roads:</u> Sedimentation that occurs in storm drain systems is often caused by erosion from construction areas as well as unpaved roads within the Town and can result in significant costs and maintenance to the system. The total amount of sedimentation in the storm drain system can be greatly reduced or eliminated by paving or chip sealing unimproved roads. Most of these roadways are private and the town is not responsible to improve or maintain these dirt roads. It is recommended that privately held owners improve the dirt roads.
- <u>Install Curb and Gutter:</u> Some streets in Springdale do not have complete curb and gutter systems which control runoff from the street. The Town may consider requiring curb and gutter on street improvements.
- <u>Complete Regular Street Sweeping:</u> A comprehensive street sweeping and cleanup program should be developed to remove sediment and trash from the streets and gutters so debris is not washed to downstream storm drain control facilities and into the natural washes and the Virgin River. It is anticipated that this simple maintenance procedure will greatly reduce future costs for maintenance of the storm drain system.
- <u>Complete Regular Facility Cleaning</u>: A comprehensive facility maintenance program should be established to clean inlet boxes, manholes, pipe systems, and any future pollution control structures. Regular maintenance will ensure the proper functionality of these structures, prolong life expectancy and reduce future maintenance costs.
- <u>Ensure Proper Grate Orientation</u>: Many of the catch basins in the Town of Springdale storm drain system are fitted with directional grates which must be installed in the correct orientation to function at maximum efficiency. Maintenance of the storm drain system should include a procedure to ensure that the grates on every catch basin are oriented properly.
- <u>Establish Standard Maintenance Program</u>: It is recommended that the Town of Springdale develop a regular storm drain system maintenance program with proper tracking and record keeping. This process is most easily accomplished using current computer technology including the Town's existing GIS base map to provide the foundation for this mapping and record keeping software. Implementing such a system will allow the Town to maintain the storm drain system at the highest level of efficiency.
- <u>Updating Storm Drain System Map</u>: It is strongly recommended that the Town of Springdale continue to update a thorough storm drain system map.

Having the map will significantly reduce storm drain system maintenance costs.

- Create Storm Drain Utility: The creation of a distinct storm drain utility in the Town of Springdale may aid, both administratively and financially, in the maintenance of the storm drain system. The town council can discuss this to see if having a rate structure would add benefit to the town.

## F. WATER QUALITY MANAGEMENT MEASURES

One of the primary goals of a stormwater management plan is to enhance the quality of water discharged to downstream stormwater conveyance facilities. Runoff generated from urban and suburban areas often contains pollutants such as sediments, road salts, oils, greases, solvents, pesticides, fertilizers, detergents, trash and many other forms of pollutants which may be discharged to downstream rivers and lakes. The Environmental Protection Agency (EPA) requires that these pollutants be controlled, mitigated and otherwise eliminated before they are discharged.

The first line of defense against pollution discharges are detention basin facilities installed near low segments of storm drain systems. Detention basins or hydromarine separators control peak flows that would otherwise be routed directly to receiving discharge facilities. As stormwater runoff is held in the detention basin or separator, flow velocity of the water is minimized and many of the suspended pollutants are able to settle out. Some of the pollutants are broken down organically while the physical debris, such as trash and sediment, can be manually cleaned from the detention basin or separator and disposed of properly. This study recommends installation of local detention basin or separator facilities in future developments in the Town. These would be implemented by individual developers. The Town may consider placing separators at the end of each existing major piping system to reduce the amount of sediment currently being put into the Virgin River. The hydromarine separators would need to be maintained more regularly than the detention basin; however, they can be located on a tighter site. If the hydromarine separator is overwhelmed by debris, then the water will simply flow over the inlet and continue to the river as it would prior to the installation.

The second line of defense against pollution discharges are Best Management Practice (BMP) structures such as oil and grease separation structures. These structures are devices that are designed to remove oils, grease and other similar materials from stormwater before it is discharged to downstream receiving facilities. Figure IV.F.1 in Appendix A is a diagram of an oil/water separator. It is recommended that a structure of this type be installed at each of the detention basins to ensure that these pollutant types are removed from stormwater before it is discharged to the washes throughout the Town and into the Virgin River. It should be noted that these facilities require regular maintenance. If not cleaned and maintained properly, these devices cease to function and no pollutants are removed from the discharge flows.

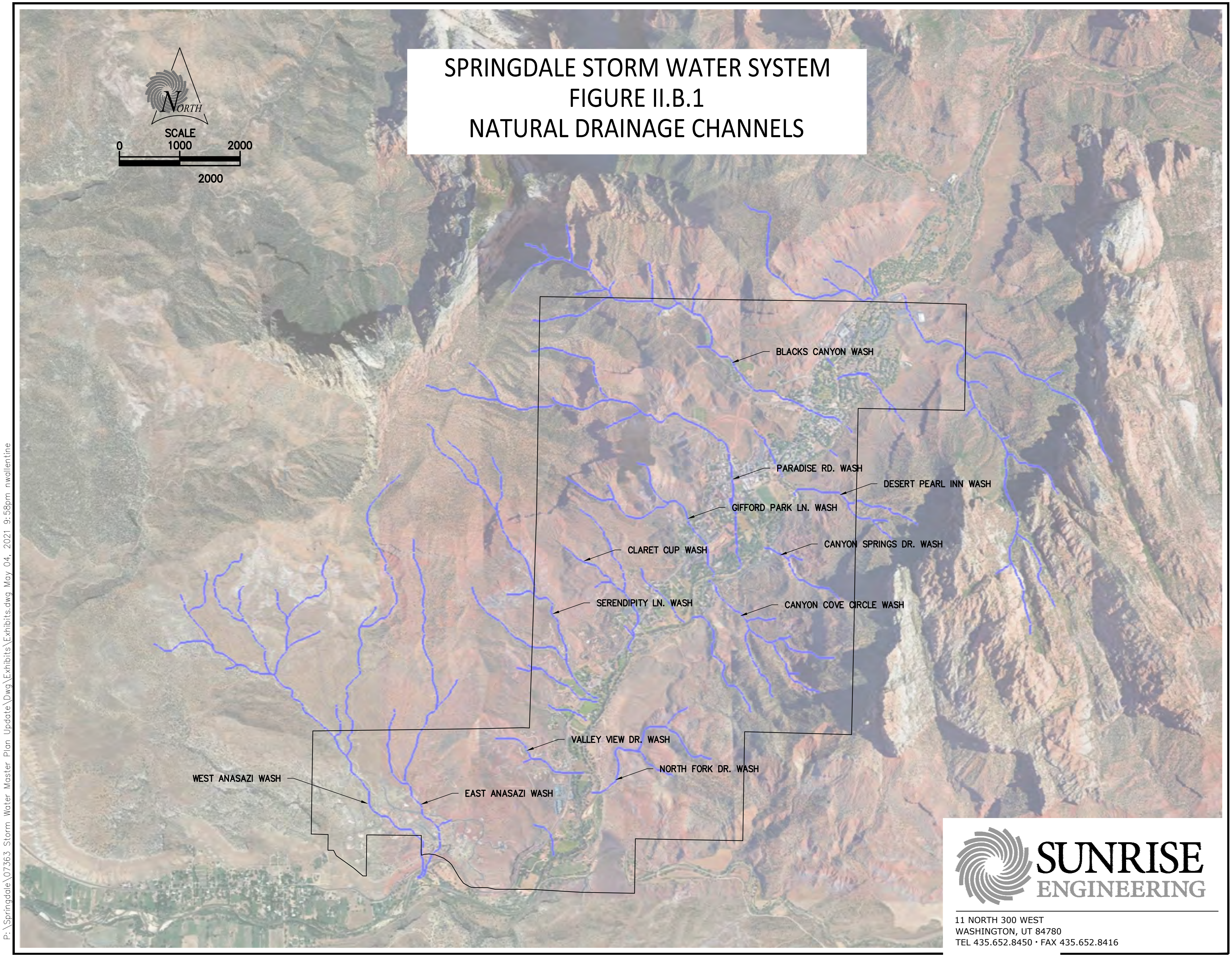
# V. COST

## A. SYSTEM IMPROVEMENT

The recommended storm drain improvements were outlined in the System Improvements List given in the previous section of this study. Unit costs were applied to the recommended improvements and cost estimates were derived for the purpose of future financial planning. The Town anticipates that each project will be taken care of individually. Therefore, to better accommodate the needs of the Town, each project cost estimate was done individually. Table V.A.1 in Appendix B is the Engineer's Opinion of Probable Cost for each of the recommended improvements. It should be noted that these cost estimates are based on current 2021, market prices and these probable costs show the opined construction costs excluding professional fees. If, in the event the Town needs professional assistance for design, bidding, and construction administration it can be handled on a case by case basis as needed.

# APPENDIX A – MASTER PLAN FIGURES

# SPRINGDALE STORM WATER SYSTEM
## FIGURE II.B.1
## NATURAL DRAINAGE CHANNELS

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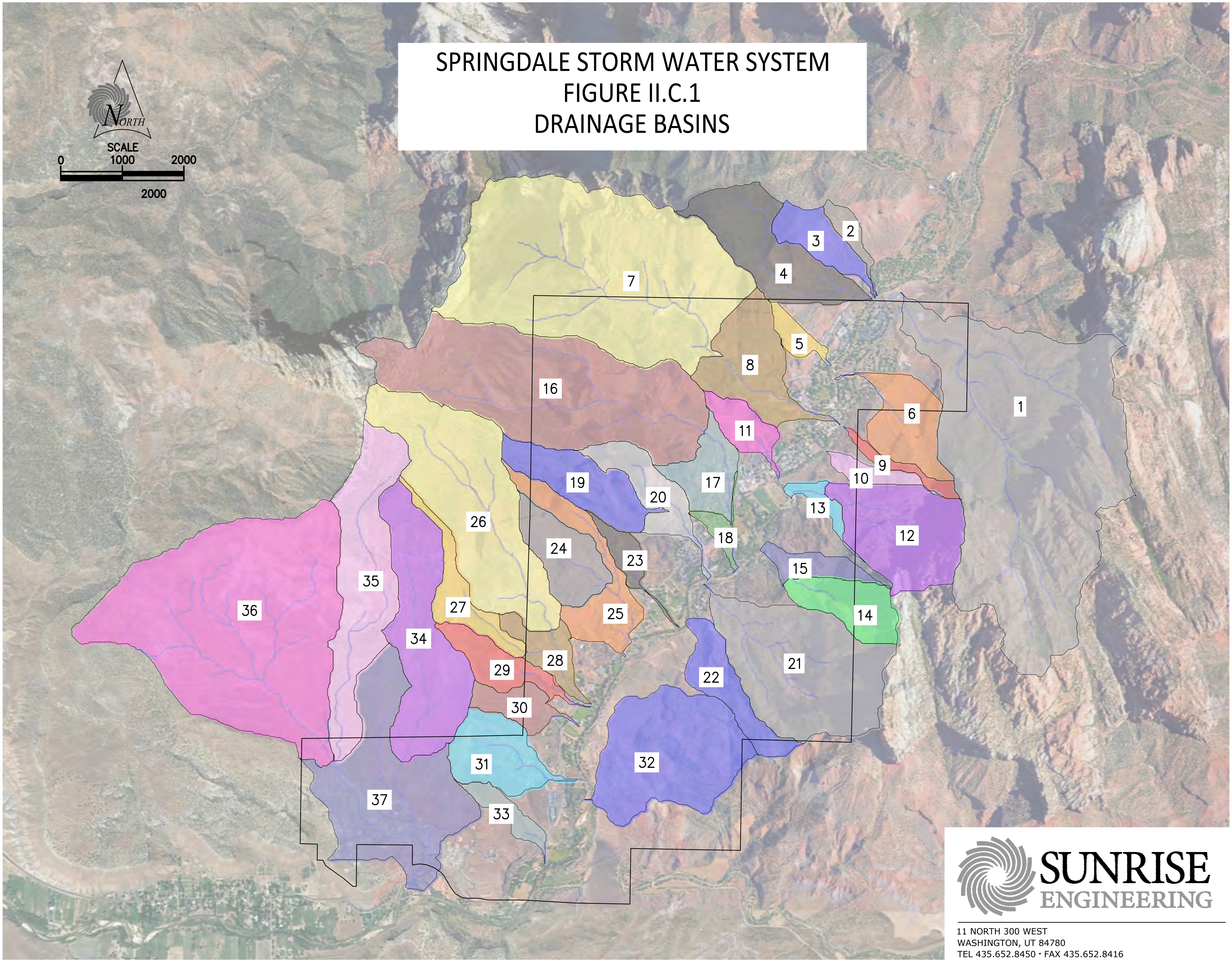
# SPRINGDALE STORM WATER SYSTEM
# FIGURE II.C.1
# DRAINAGE BASINS

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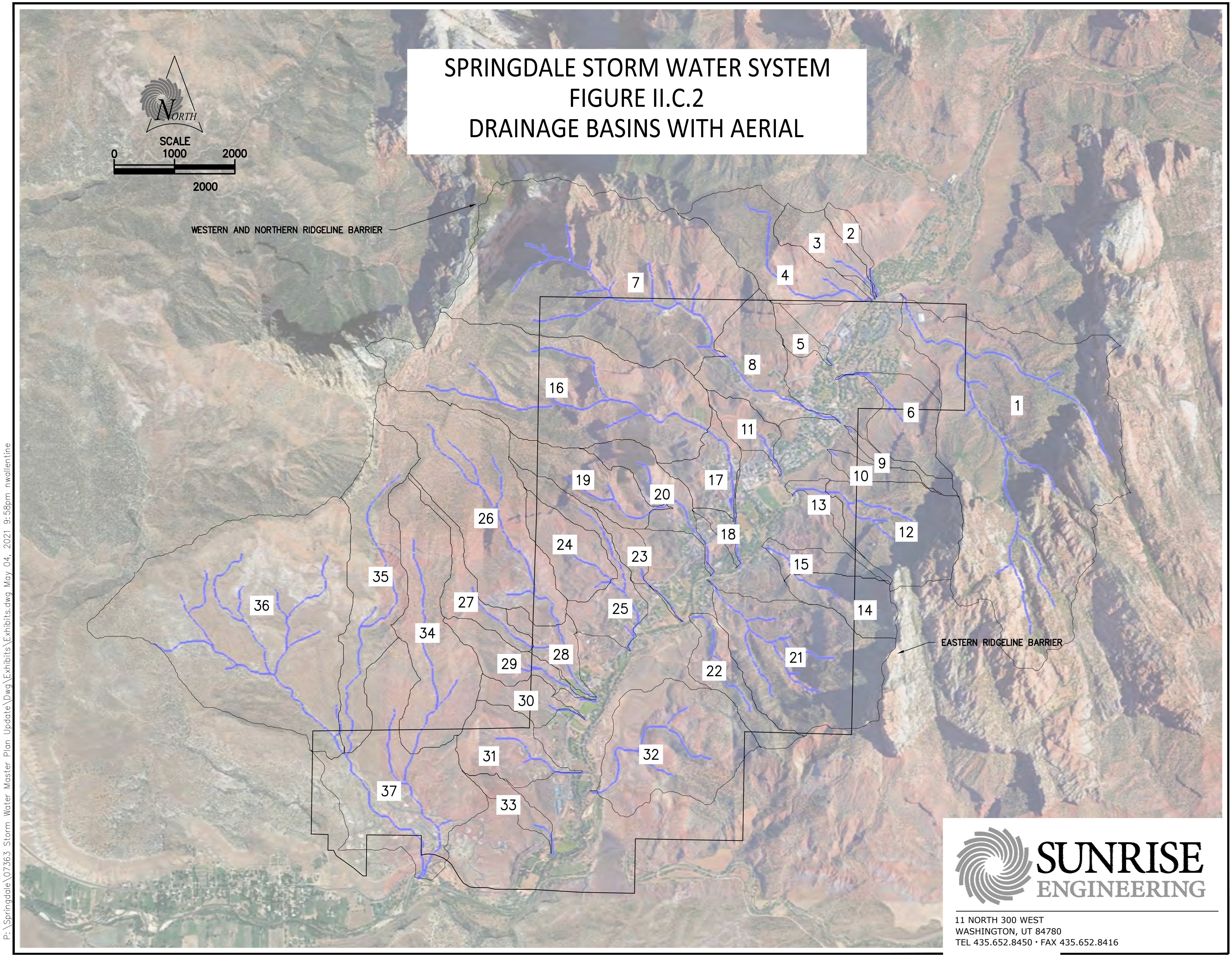
# SPRINGDALE STORM WATER SYSTEM
# FIGURE II.C.2
# DRAINAGE BASINS WITH AERIAL

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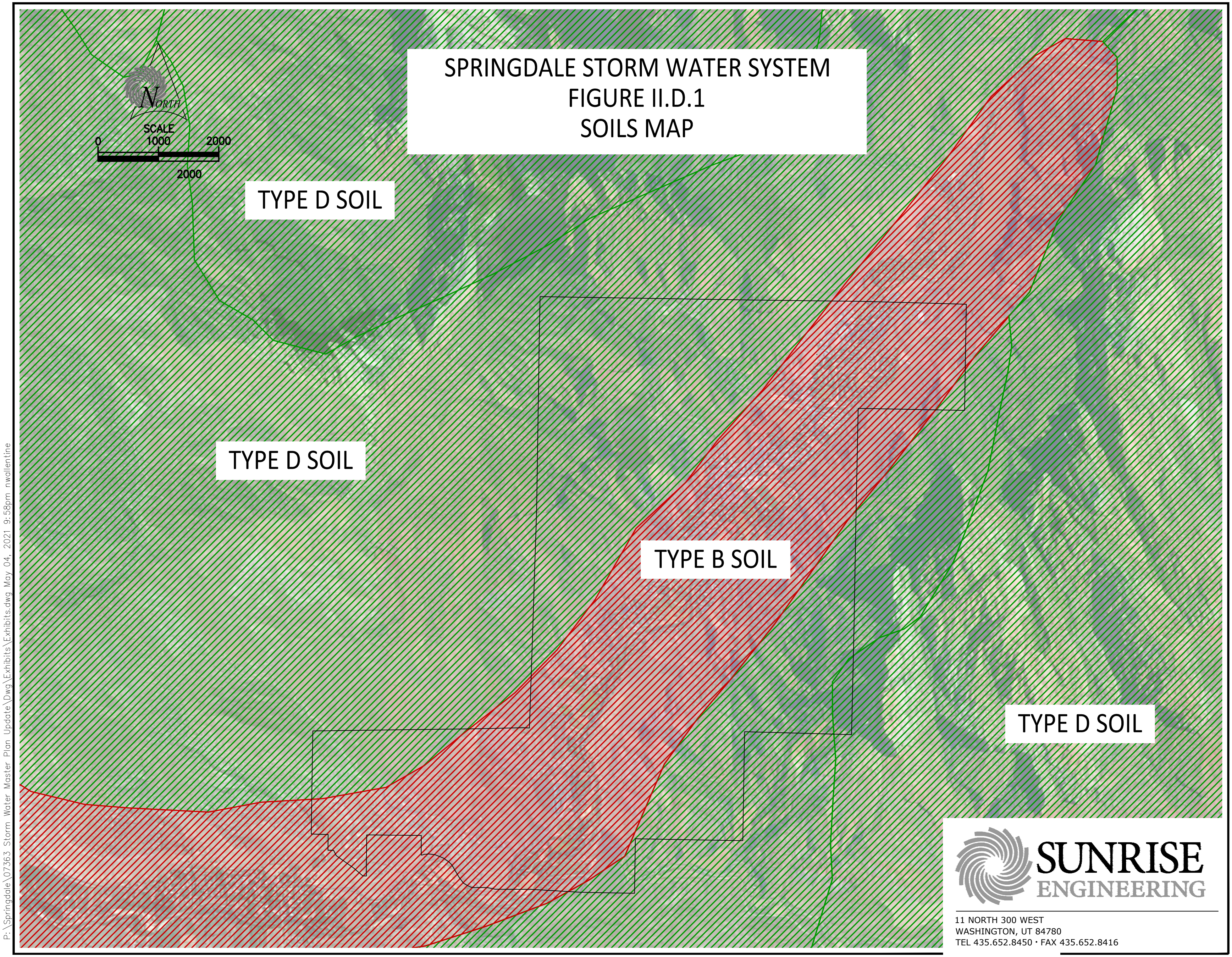
SPRINGDALE STORM WATER SYSTEM
FIGURE II.D.1
SOILS MAP
NORTH
SCALE
0
1000
2000
2000
TYPE D SOIL
TYPE D SOIL
TYPE B SOIL
TYPE D SOIL
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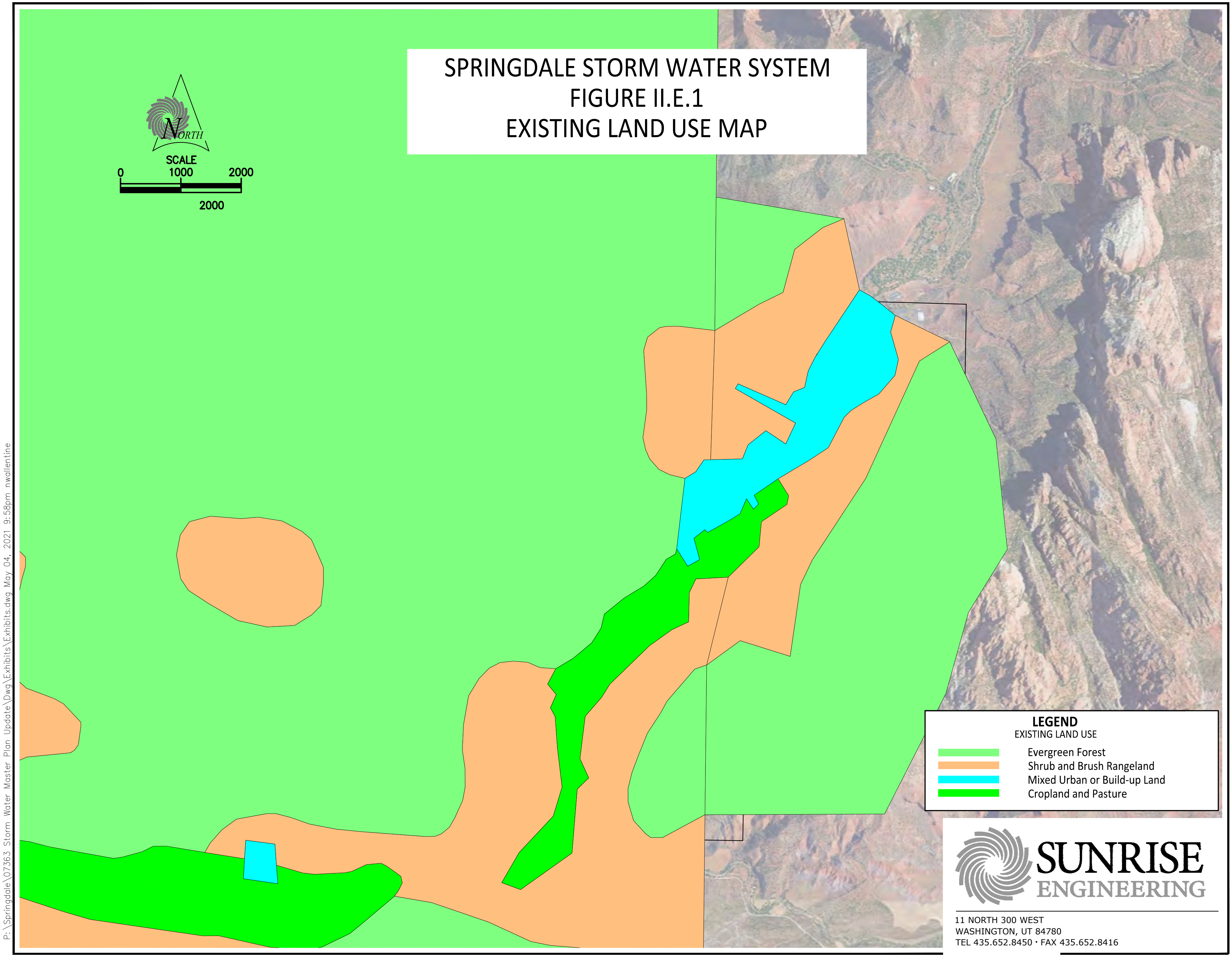


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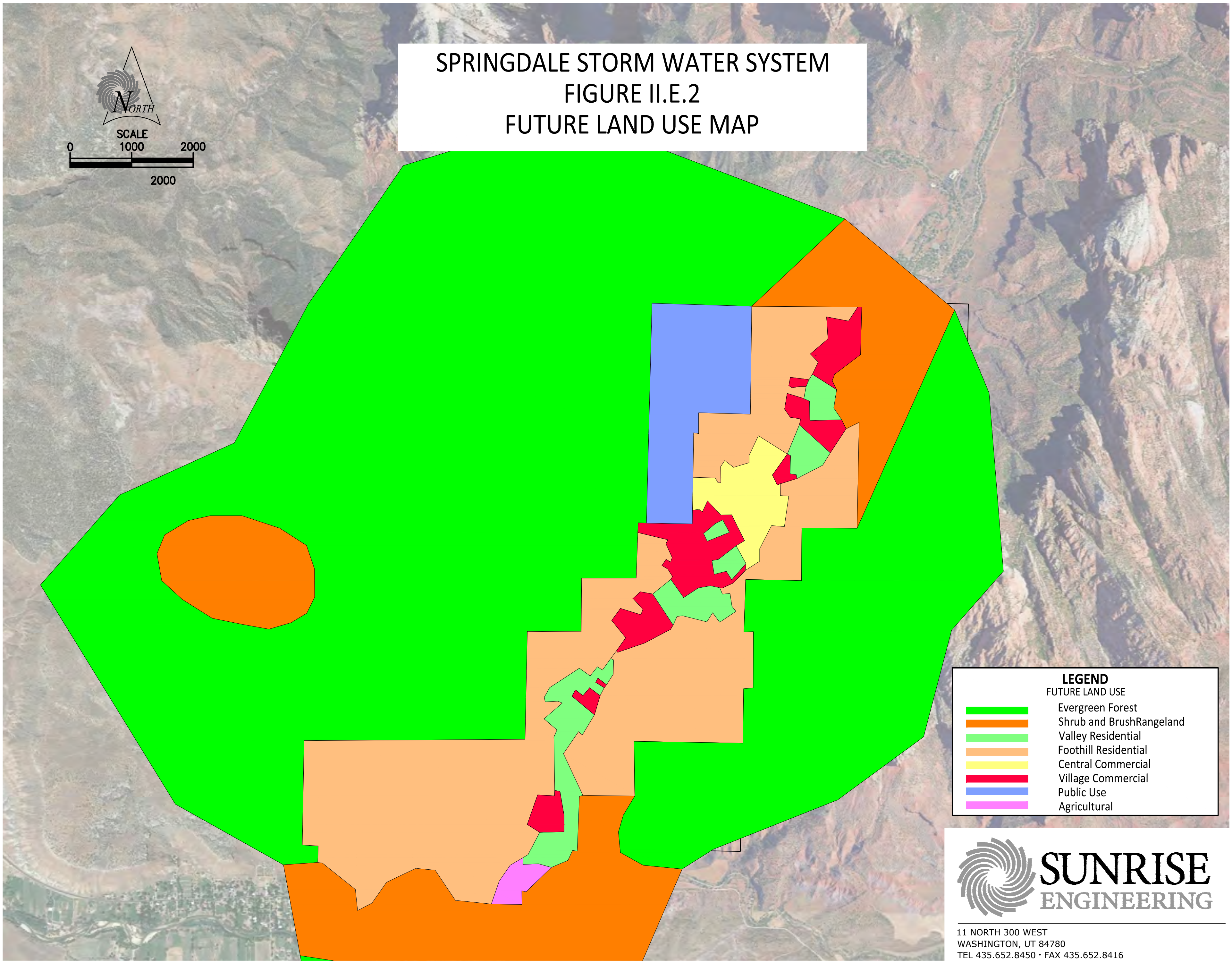


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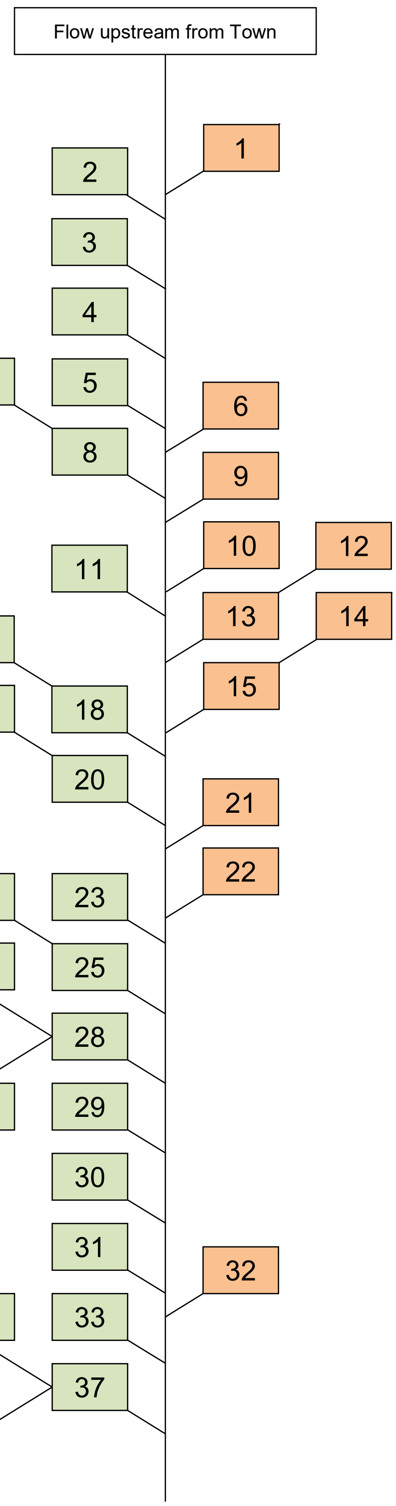
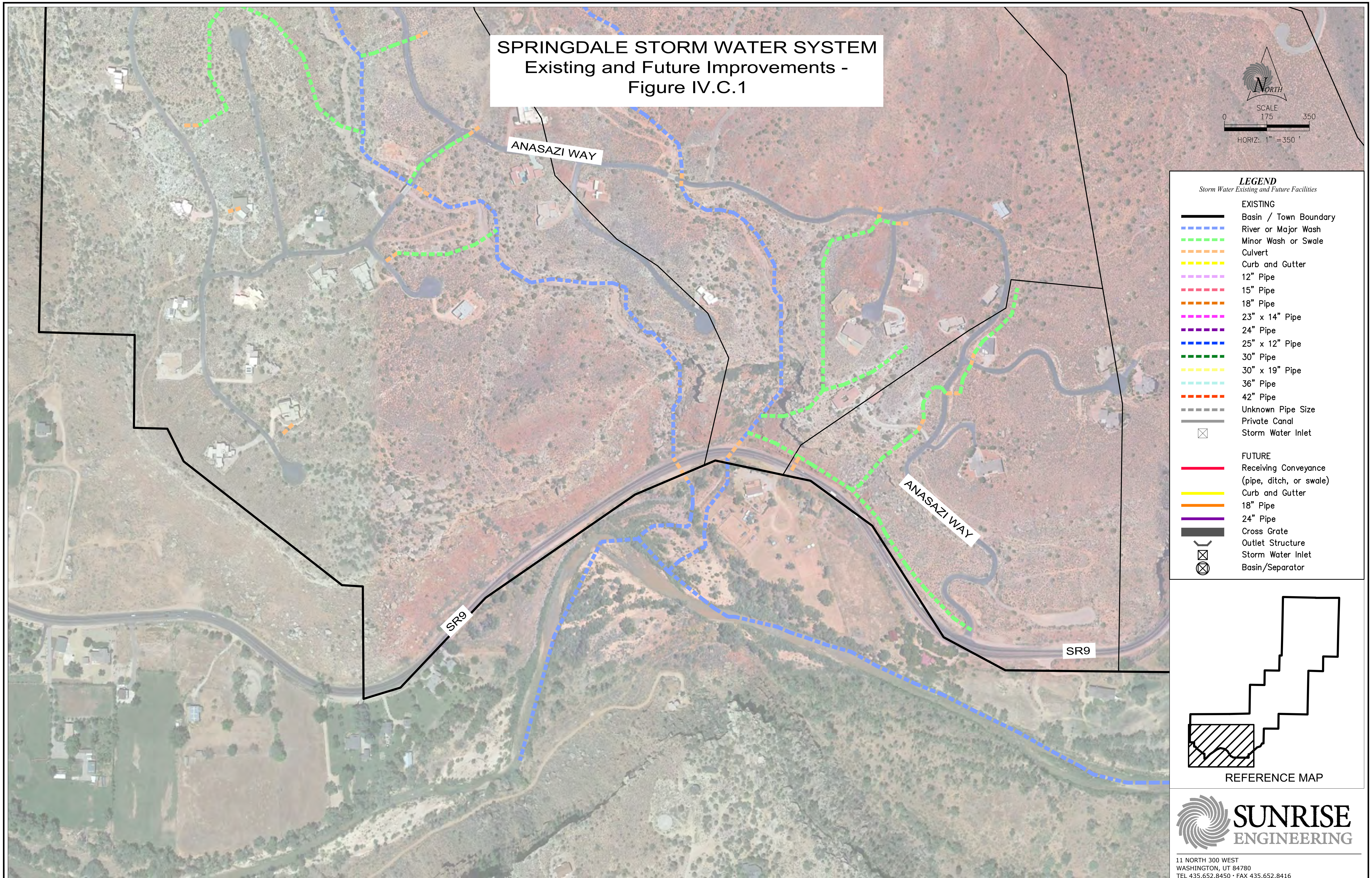
Figure III.C.1 - Drainage Flow Chart

Storm water facilities into washes on the western side of the Virgin River

Storm water facilities into washes on the eastern side of the Virgin River




SPRINGDALE STORM WATER SYSTEM
Existing and Future Improvements -
Figure IV.C.1
ANASAZI WAY
ANASAZI WAY
SR9
SR9
NORTH
SCALE
0 175 350
HORIZ: 1" =350 '
LEGEND
Storm Water Existing and Future Facilities
EXISTING
Basin / Town Boundary
River or Major Wash
Minor Wash or Swale
Culvert
Curb and Gutter
12" Pipe
15" Pipe
18" Pipe
23" x 14" Pipe
24" Pipe
25" x 12" Pipe
30" Pipe
30" x 19" Pipe
36" Pipe
42" Pipe
Unknown Pipe Size
Private Canal
Storm Water Inlet
FUTURE
Receiving Conveyance
(pipe, ditch, or swale)
Curb and Gutter
18" Pipe
24" Pipe
Cross Grate
Outlet Structure
Storm Water Inlet
Basin/Separator
REFERENCE MAP
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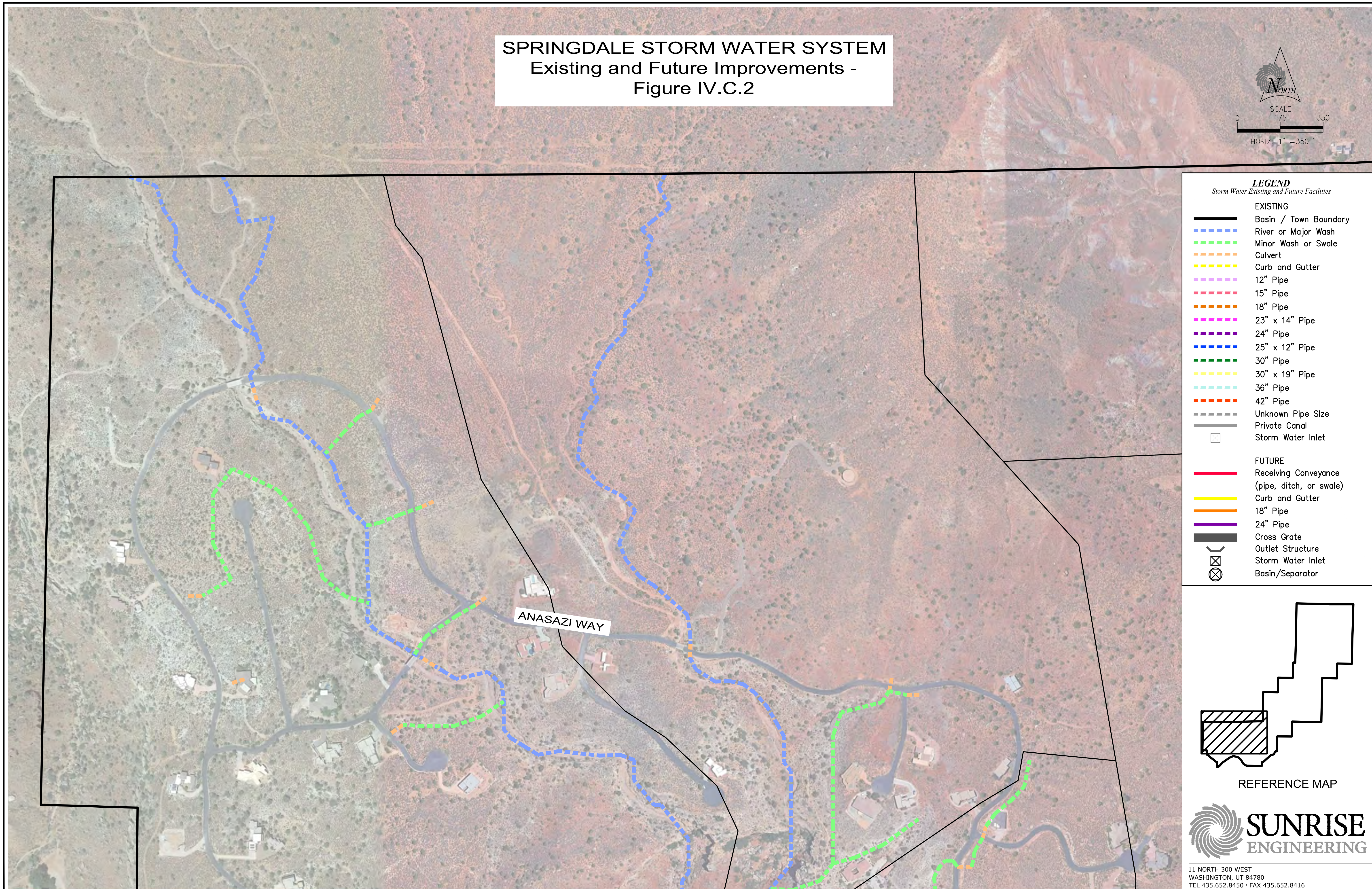

SPRINGDALE STORM WATER SYSTEM
Existing and Future Improvements -
Figure IV.C.2
NORTH
SCALE
0
175
350
HORIZ: 1" =350 '
ANASAZI WAY
LEGEND
Storm Water Existing and Future Facilities
EXISTING
Basin / Town Boundary
River or Major Wash
Minor Wash or Swale
Culvert
Curb and Gutter
12" Pipe
15" Pipe
18" Pipe
23" x 14" Pipe
24" Pipe
25" x 12" Pipe
30" Pipe
30" x 19" Pipe
36" Pipe
42" Pipe
Unknown Pipe Size
Private Canal
Storm Water Inlet
FUTURE
Receiving Conveyance
(pipe, ditch, or swale)
Curb and Gutter
18" Pipe
24" Pipe
Cross Grate
Outlet Structure
Storm Water Inlet
Basin/Separator
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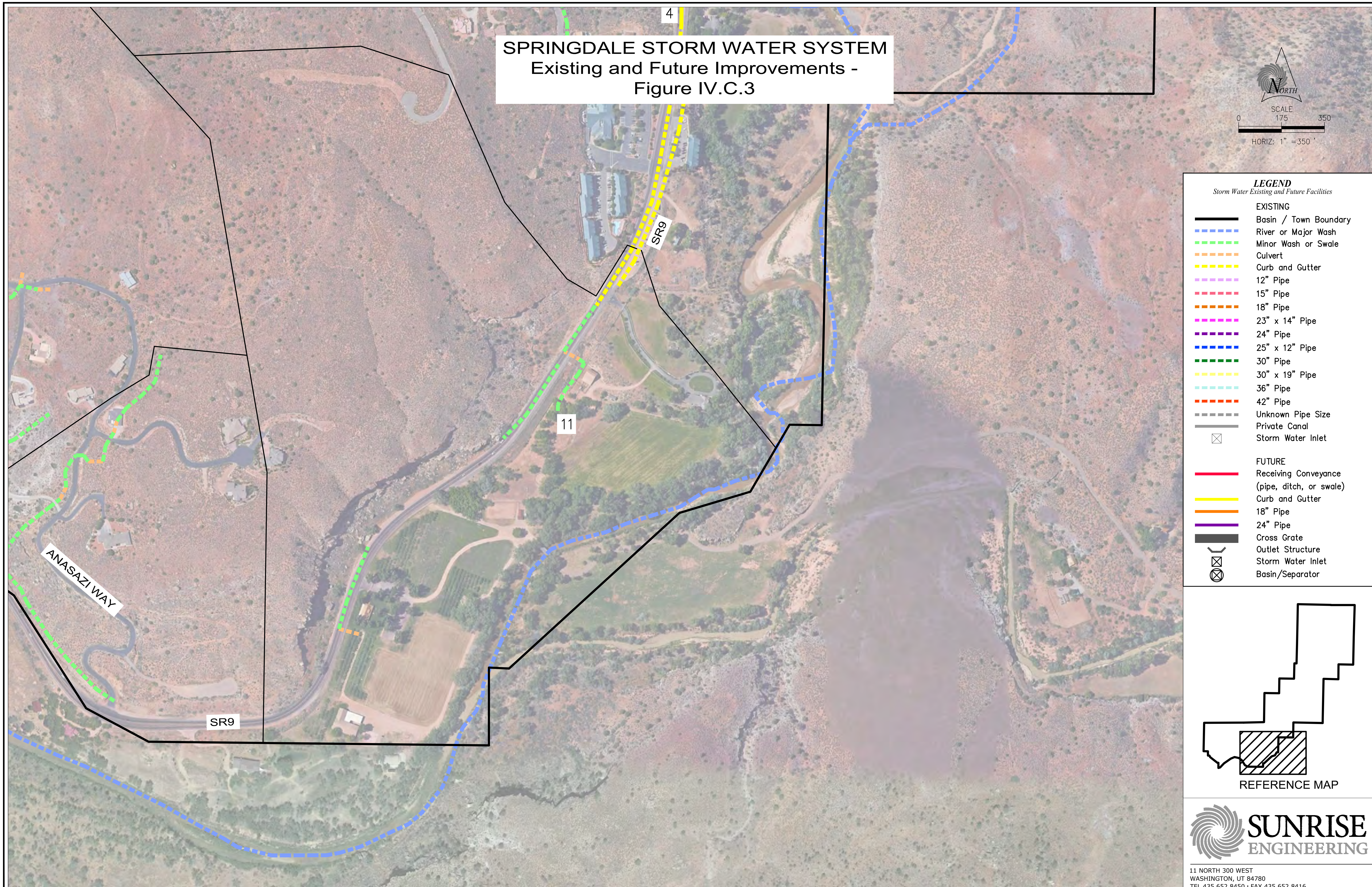
SPRINGDALE STORM WATER SYSTEM
Existing and Future Improvements -
Figure IV.C.3
4
SR9
11
ANASAZI WAY
SR9
NORTH
SCALE
0
175
350
HORIZ: 1" =350 '
LEGEND
Storm Water Existing and Future Facilities
EXISTING
Basin / Town Boundary
River or Major Wash
Minor Wash or Swale
Culvert
Curb and Gutter
12" Pipe
15" Pipe
18" Pipe
23" x 14" Pipe
24" Pipe
25" x 12" Pipe
30" Pipe
30" x 19" Pipe
36" Pipe
42" Pipe
Unknown Pipe Size
Private Canal
Storm Water Inlet
FUTURE
Receiving Conveyance
(pipe, ditch, or swale)
Curb and Gutter
18" Pipe
24" Pipe
Cross Grate
Outlet Structure
Storm Water Inlet
Basin/Separator
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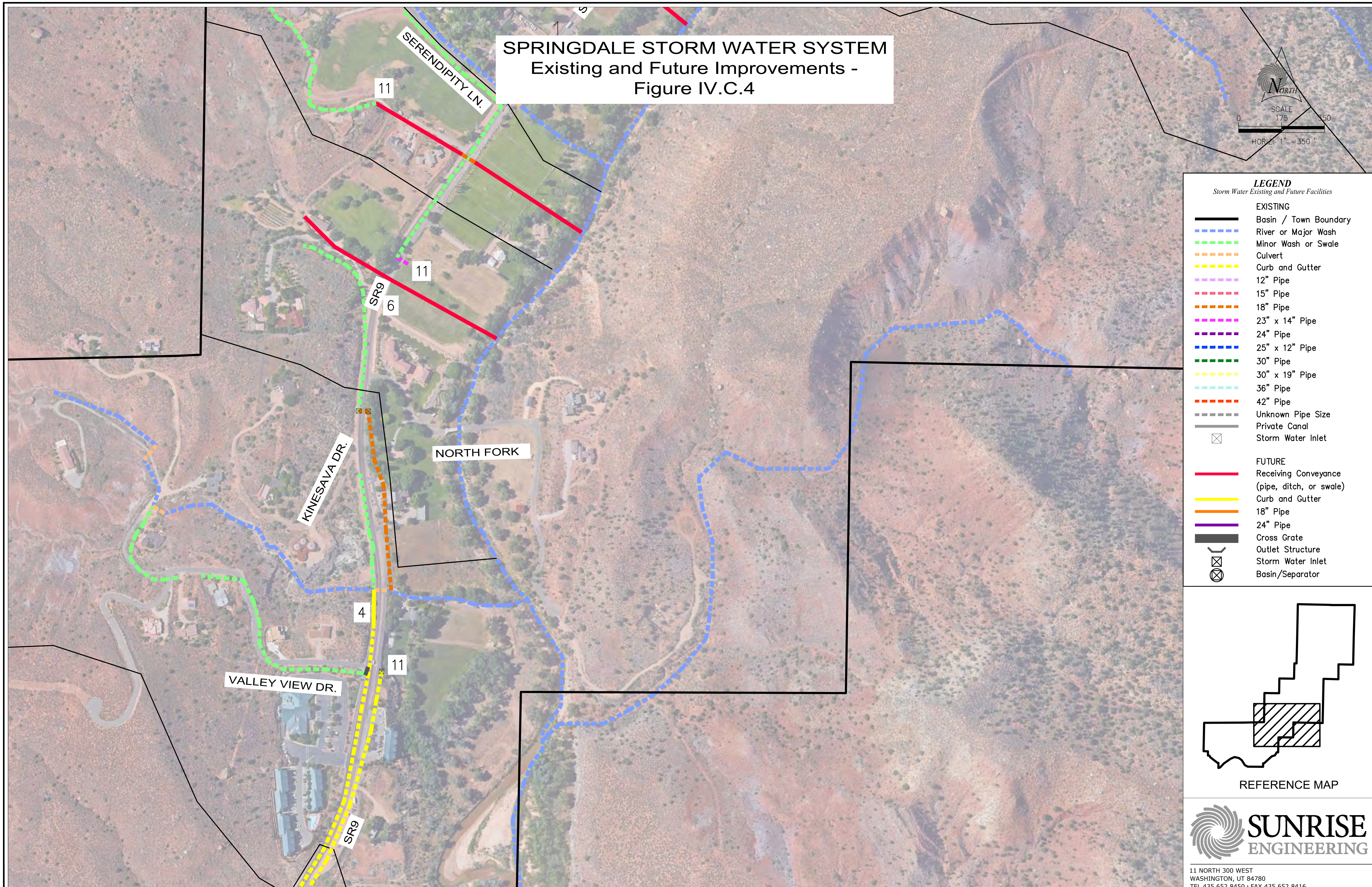
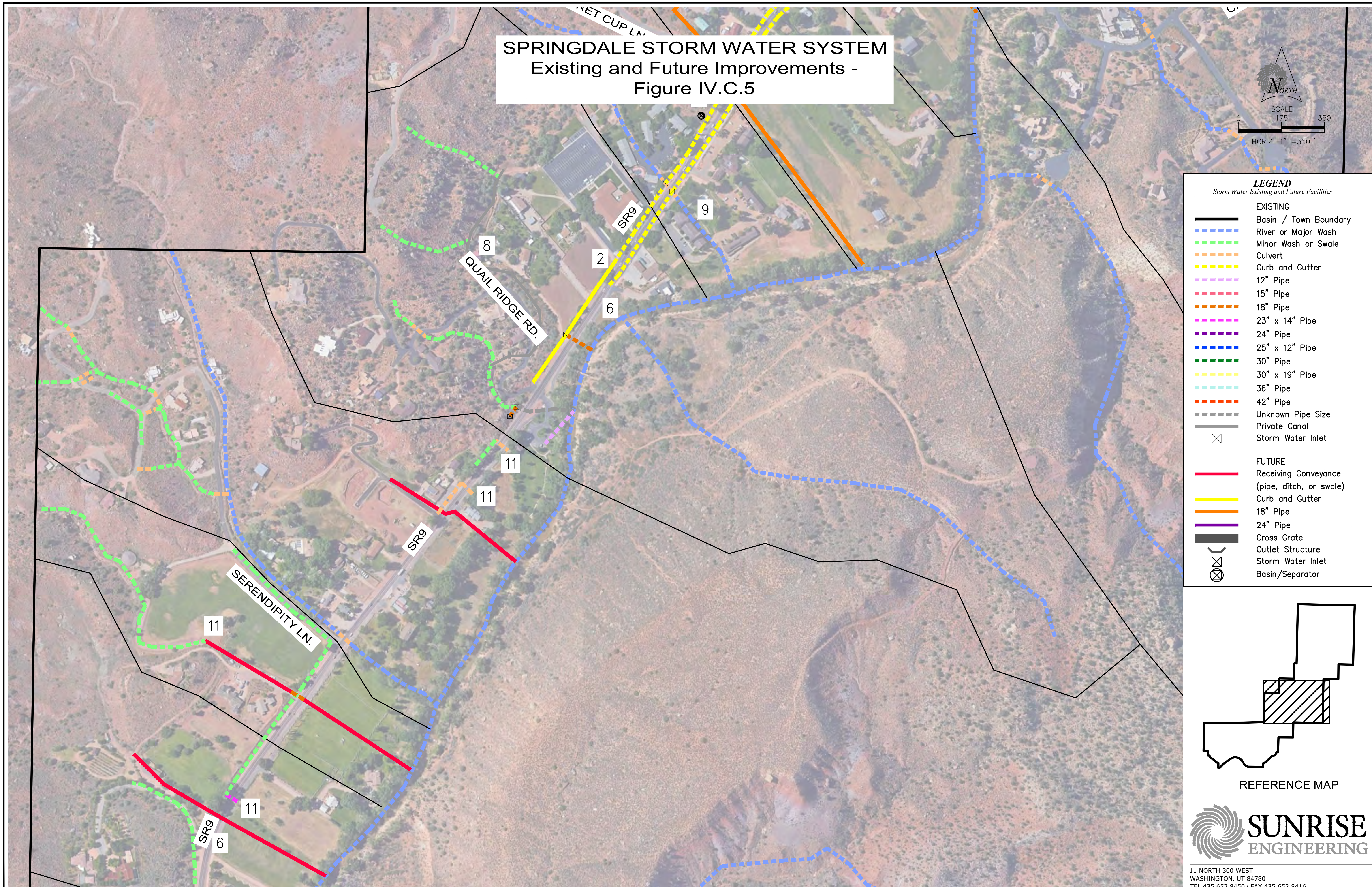
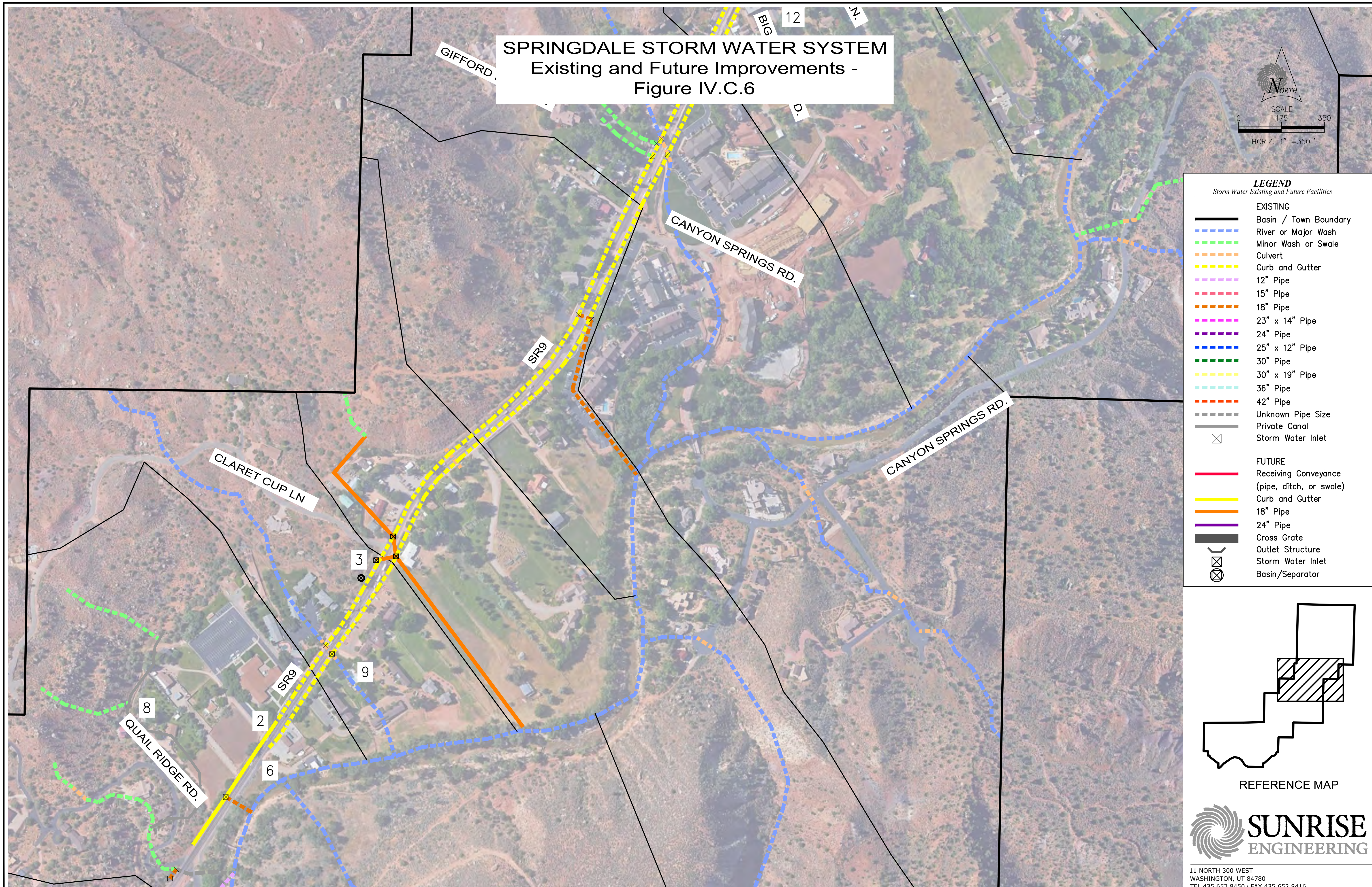
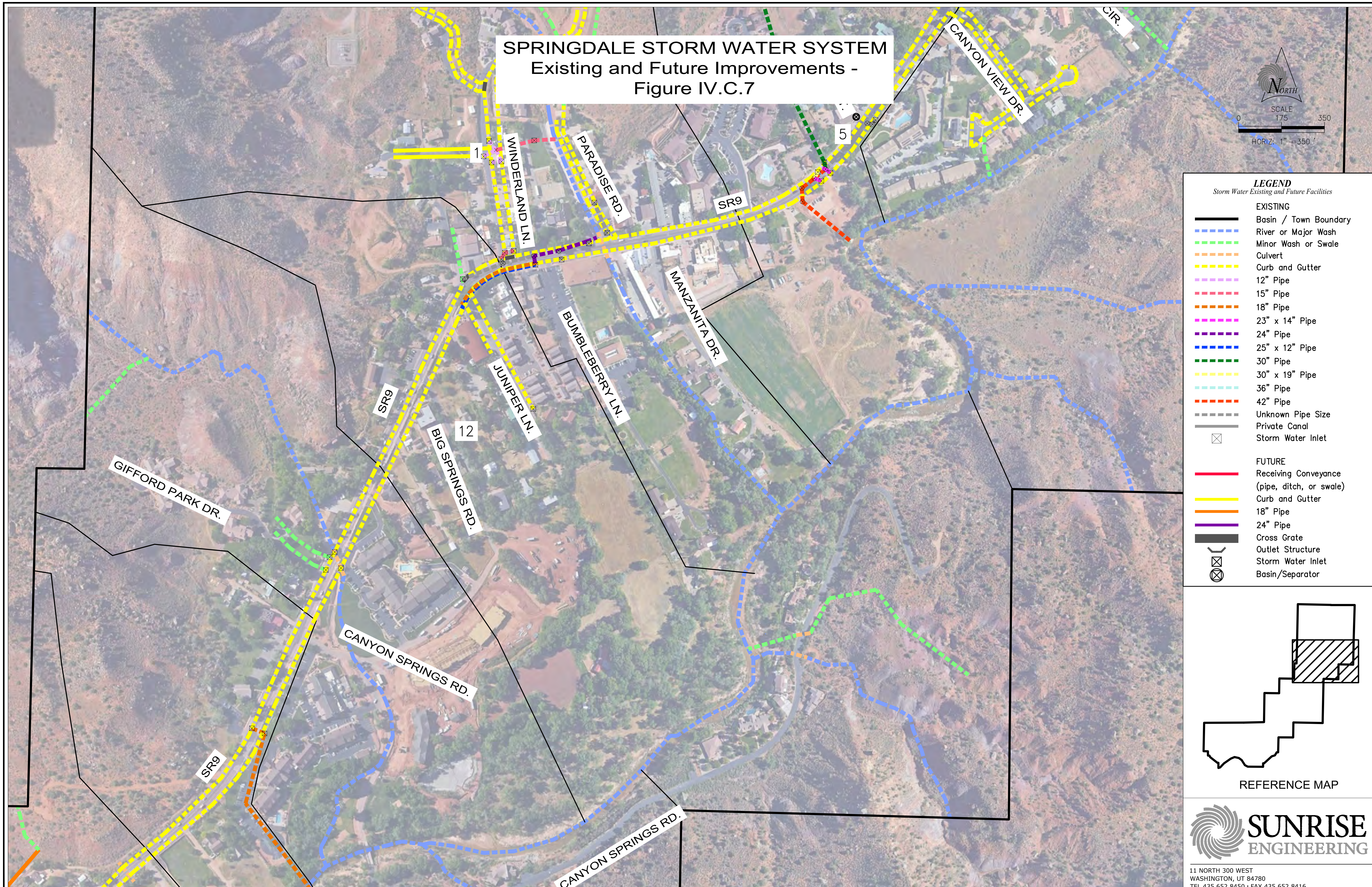
# SPRINGDALE STORM WATER SYSTEM
Existing and Future Improvements -
Figure IV.C.4



# SPRINGDALE STORM WATER SYSTEM
## Existing and Future Improvements - Figure IV.C.5




SPRINGDALE STORM WATER SYSTEM
Existing and Future Improvements -
Figure IV.C.6
GIFFORD
BIG
12
CANYON SPRINGS RD.
CANYON SPRINGS RD.
SR9
SR9
CLARET CUP LN
QUAIL RIDGE RD.
2
3
6
8
9
NORTH
SCALE
0 175 350
HORIZ: 1" =350 '
LEGEND
Storm Water Existing and Future Facilities
EXISTING
Basin / Town Boundary
River or Major Wash
Minor Wash or Swale
Culvert
Curb and Gutter
12" Pipe
15" Pipe
18" Pipe
23" x 14" Pipe
24" Pipe
25" x 12" Pipe
30" Pipe
30" x 19" Pipe
36" Pipe
42" Pipe
Unknown Pipe Size
Private Canal
Storm Water Inlet
FUTURE
Receiving Conveyance
(pipe, ditch, or swale)
Curb and Gutter
18" Pipe
24" Pipe
Cross Grate
Outlet Structure
Storm Water Inlet
Basin/Separator
REFERENCE MAP
SUNRISE
ENGINEERING
11 NORTH 300 WEST
WASHINGTON, UT 84780
TEL 435.652.8450 · FAX 435.652.8416
www.sunrise-eng.com



SPRINGDALE STORM WATER SYSTEM
Existing and Future Improvements -
Figure IV.C.7
NORTH
SCALE
0 175 350
HORIZ: 1" =350 '
LEGEND
Storm Water Existing and Future Facilities
EXISTING
Basin / Town Boundary
River or Major Wash
Minor Wash or Swale
Culvert
Curb and Gutter
12" Pipe
15" Pipe
18" Pipe
23" x 14" Pipe
24" Pipe
25" x 12" Pipe
30" Pipe
30" x 19" Pipe
36" Pipe
42" Pipe
Unknown Pipe Size
Private Canal
Storm Water Inlet
FUTURE
Receiving Conveyance
(pipe, ditch, or swale)
Curb and Gutter
18" Pipe
24" Pipe
Cross Grate
Outlet Structure
Storm Water Inlet
Basin/Separator
REFERENCE MAP
WINDERLAND LN.
PARADISE RD.
SR9
CANYON VIEW DR.
CIR.
MANZANITA DR.
BUMBLEBERRY LN.
JUNIPER LN.
BIG SPRINGS RD.
GIFFORD PARK DR.
CANYON SPRINGS RD.
CANYON SPRINGS RD.
SR9
SR9
1
5
12
SUNRISE
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11 NORTH 300 WEST
WASHINGTON, UT 84780
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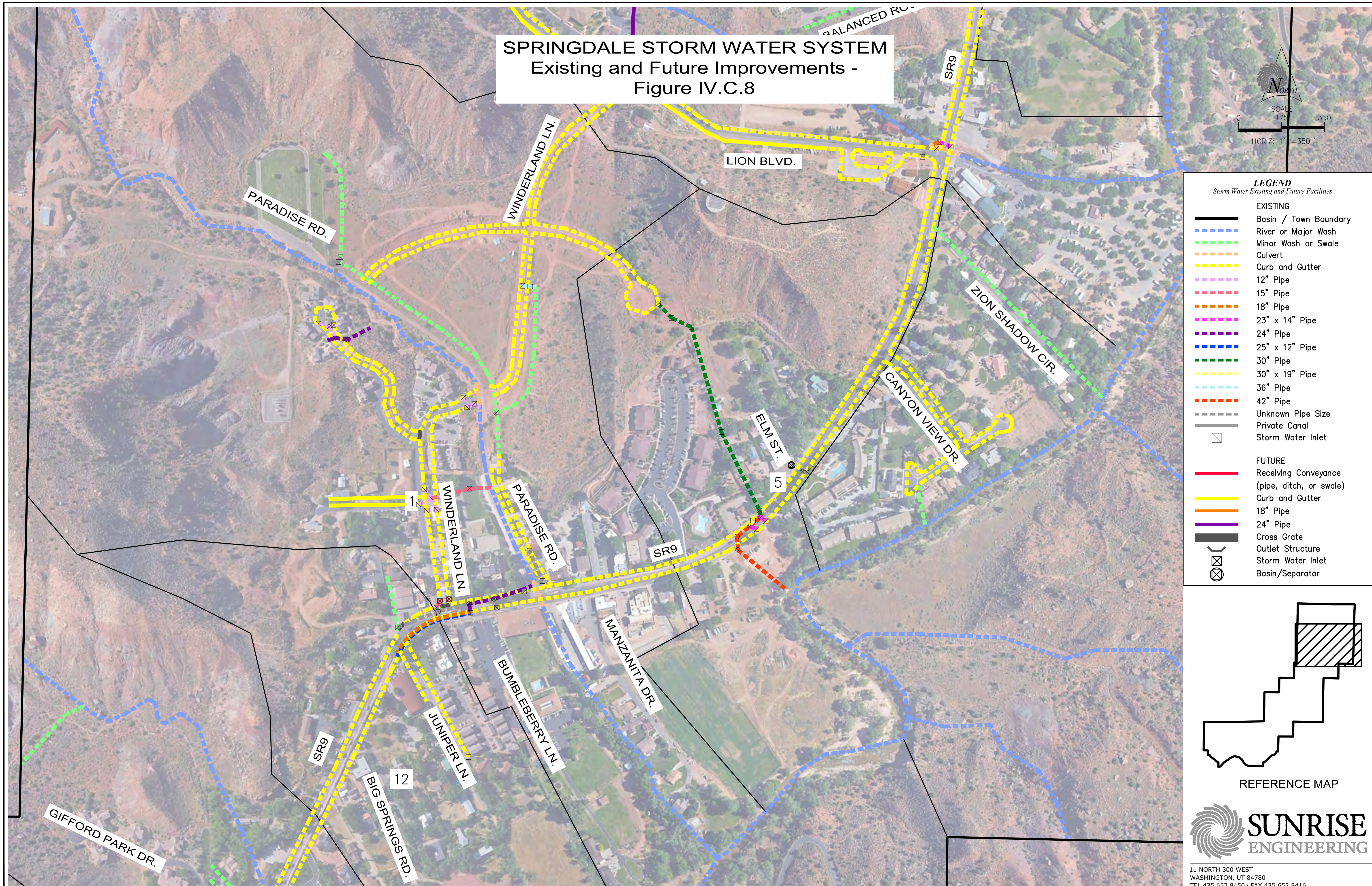
SPRINGDALE STORM WATER SYSTEM
Existing and Future Improvements -
Figure IV.C.8
LION BLVD.
PARADISE RD.
WINDERLAND LN.
SR9
ELM ST.
ZION SHADOW CIR.
CANYON VIEW DR.
MANZANITA DR.
BUMBLEBERRY LN.
JUNIPER LN.
BIG SPRINGS RD.
GIFFORD PARK DR.
1
5
12
NORTH
SCALE
0
175
350
HORIZ: 1" = 350'
LEGEND
Storm Water Existing and Future Facilities
EXISTING
Basin / Town Boundary
River or Major Wash
Minor Wash or Swale
Culvert
Curb and Gutter
12" Pipe
15" Pipe
18" Pipe
23" x 14" Pipe
24" Pipe
25" x 12" Pipe
30" Pipe
30" x 19" Pipe
36" Pipe
42" Pipe
Unknown Pipe Size
Private Canal
Storm Water Inlet
FUTURE
Receiving Conveyance
(pipe, ditch, or swale)
Curb and Gutter
18" Pipe
24" Pipe
Cross Grate
Outlet Structure
Storm Water Inlet
Basin/Separator
REFERENCE MAP
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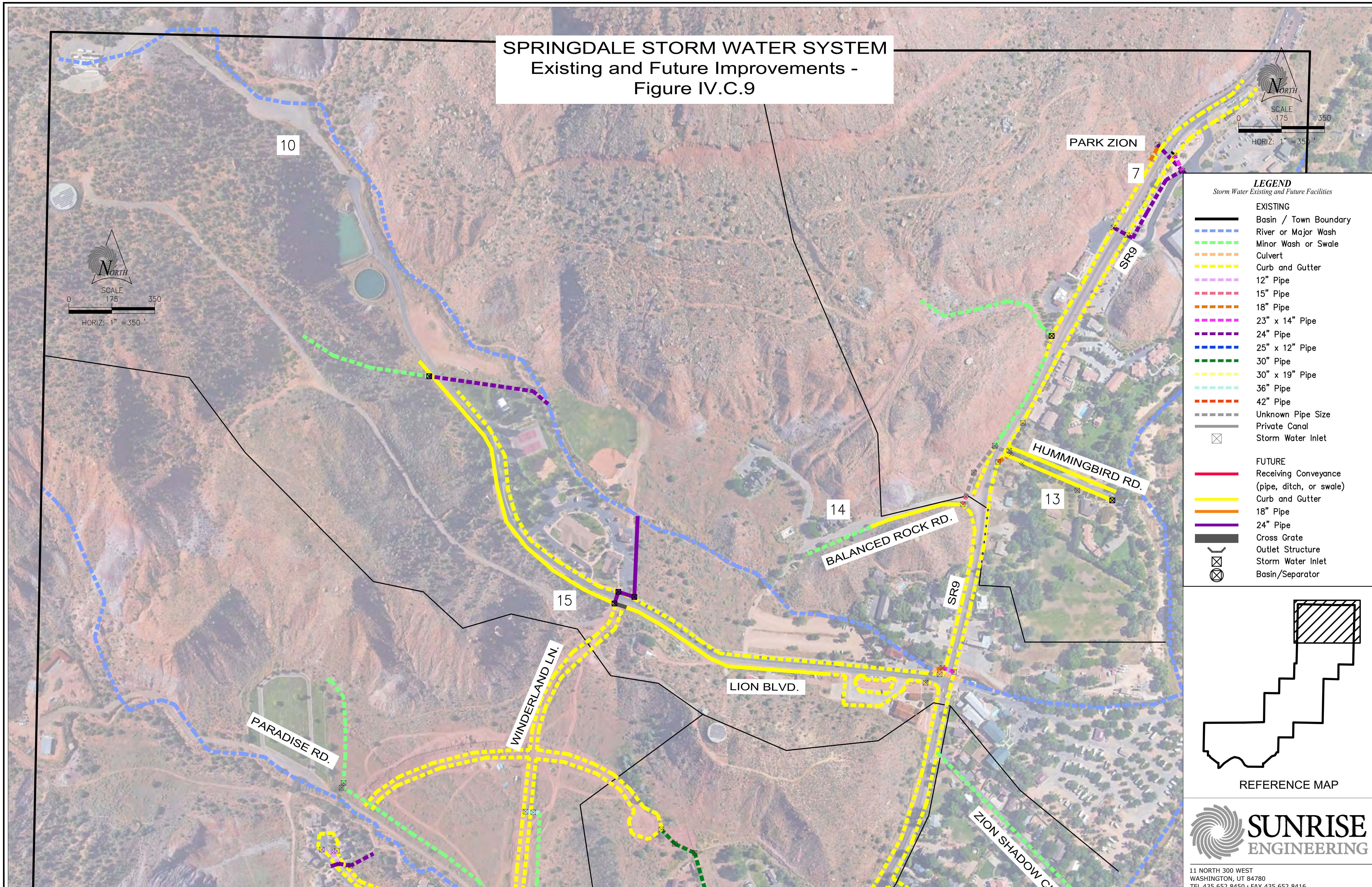
SPRINGDALE STORM WATER SYSTEM
Existing and Future Improvements -
Figure IV.C.9
10
7
13
14
15
PARK ZION
SR9
HUMMINGBIRD RD.
BALANCED ROCK RD.
LION BLVD.
WINDERLAND LN.
PARADISE RD.
ZION SHADOW CI
NORTH
SCALE
0 175 350
HORIZ: 1" =350 '
LEGEND
Storm Water Existing and Future Facilities
EXISTING
Basin / Town Boundary
River or Major Wash
Minor Wash or Swale
Culvert
Curb and Gutter
12" Pipe
15" Pipe
18" Pipe
23" x 14" Pipe
24" Pipe
25" x 12" Pipe
30" Pipe
30" x 19" Pipe
36" Pipe
42" Pipe
Unknown Pipe Size
Private Canal
Storm Water Inlet
FUTURE
Receiving Conveyance
(pipe, ditch, or swale)
Curb and Gutter
18" Pipe
24" Pipe
Cross Grate
Outlet Structure
Storm Water Inlet
Basin/Separator
REFERENCE MAP
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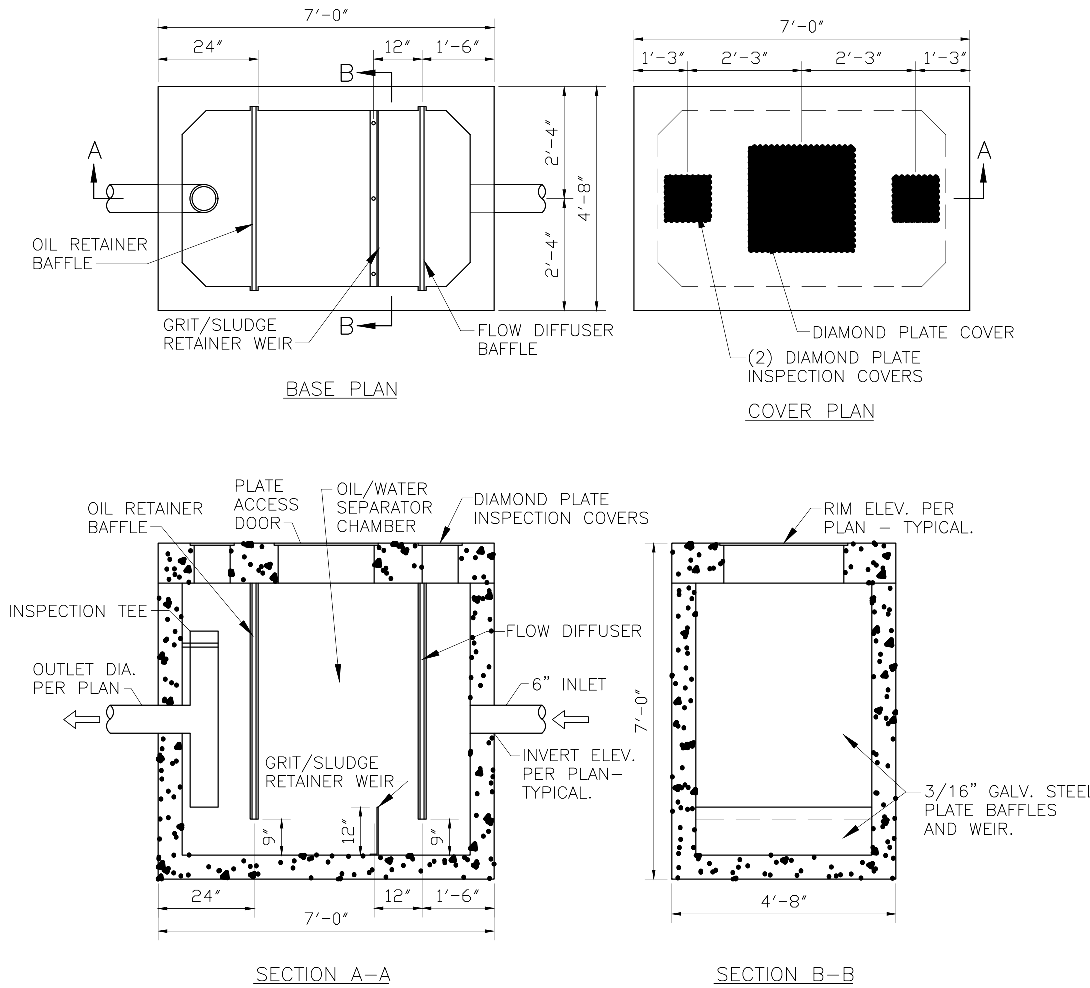
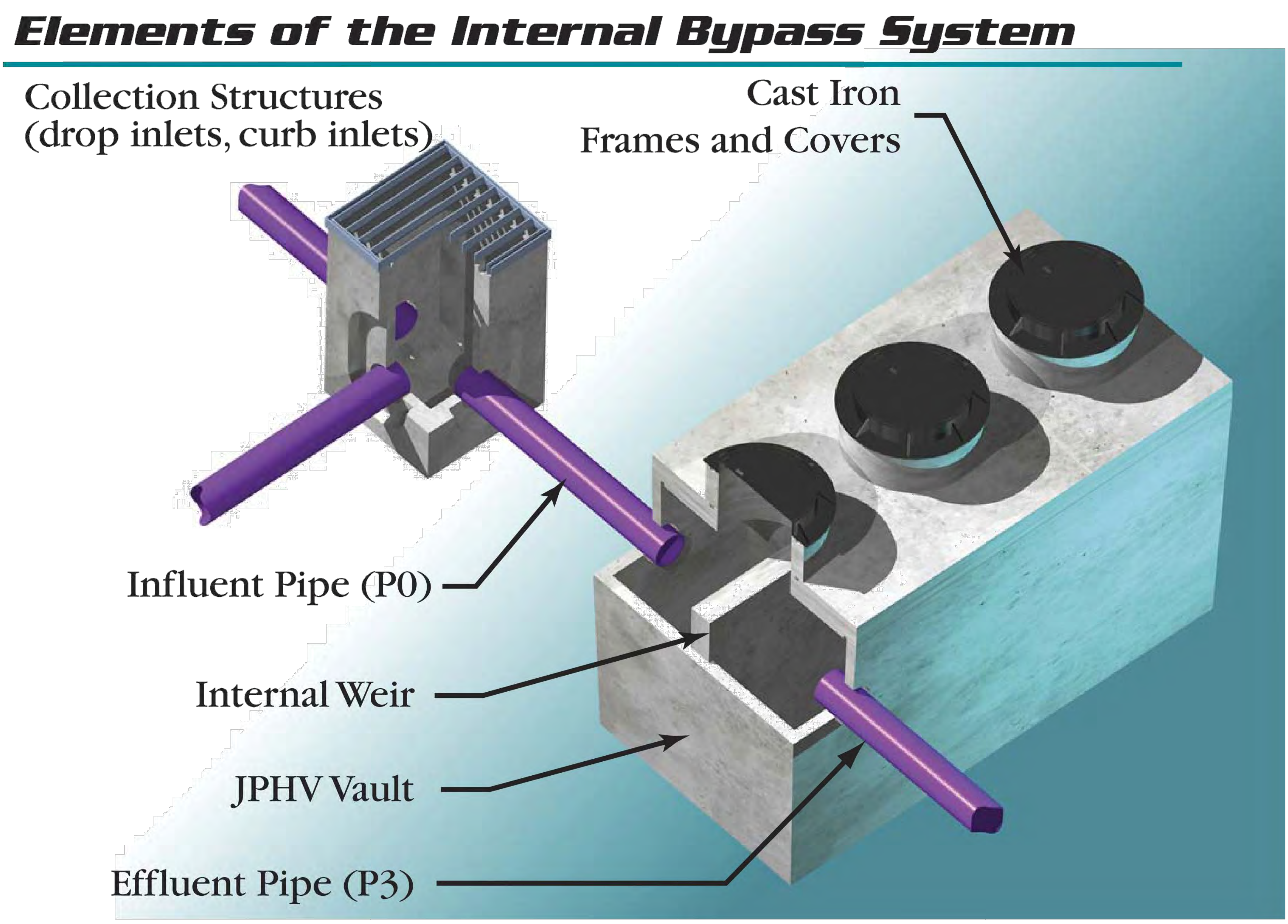
# SPRINGDALE STORM WATER SYSTEM
## Figure IV.F.1
## Oil/Water Seperator & Hydromarine Separator




OIL/WATER SEPARATOR
SCALE – 1"=4'




JENSEN PRECAST HYDROMARINE SEPARATOR
NOT TO SCALE


SUNRISE ENGINEERING
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# APPENDIX B – MASTER PLAN TABLES

Table III.B.1

Depth-Duration-Frequency of Rainfall

DURATION

| FREQUENCY | 5-min: | 10-min: | 15-min: | 30-min: | 60-min: | 2-hr: | 3-hr: | 6-hr: | 12-hr: | 24-hr: | 2-day: | 4-day: | 7-day: | 10-day: | 20-day: | 30-day: | 45-day: | 60-day: |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2 | 0.182 | 0.277 | 0.343 | 0.462 | 0.572 | 0.678 | 0.756 | 0.943 | 1.21 | 1.55 | 1.76 | 2.06 | 2.4 | 2.66 | 3.39 | 4.14 | 4.97 | 5.84 |
| 5 | 0.251 | 0.382 | 0.474 | 0.638 | 0.79 | 0.902 | 0.983 | 1.2 | 1.51 | 1.93 | 2.2 | 2.57 | 3.01 | 3.38 | 4.21 | 5.13 | 6.24 | 7.34 |
| 10 | 0.313 | 0.476 | 0.59 | 0.794 | 0.983 | 1.11 | 1.18 | 1.41 | 1.76 | 2.24 | 2.56 | 2.99 | 3.5 | 3.95 | 4.87 | 5.9 | 7.22 | 8.52 |
| 25 | 0.408 | 0.621 | 0.77 | 1.04 | 1.28 | 1.42 | 1.48 | 1.72 | 2.1 | 2.68 | 3.05 | 3.58 | 4.18 | 4.75 | 5.74 | 6.9 | 8.53 | 10.1 |
| 50 | 0.492 | 0.75 | 0.93 | 1.25 | 1.55 | 1.69 | 1.74 | 1.98 | 2.37 | 3.01 | 3.44 | 4.04 | 4.7 | 5.38 | 6.41 | 7.65 | 9.53 | 11.3 |
| 100 | 0.591 | 0.9 | 1.12 | 1.5 | 1.86 | 2.01 | 2.05 | 2.26 | 2.65 | 3.37 | 3.84 | 4.52 | 5.25 | 6.04 | 7.09 | 8.4 | 10.5 | 12.6 |
| 200 | 0.705 | 1.07 | 1.33 | 1.79 | 2.22 | 2.38 | 2.41 | 2.62 | 2.96 | 3.74 | 4.26 | 5.02 | 5.82 | 6.72 | 7.77 | 9.13 | 11.6 | 13.8 |
| 500 | 0.884 | 1.35 | 1.67 | 2.25 | 2.78 | 2.97 | 2.98 | 3.2 | 3.44 | 4.24 | 4.82 | 5.71 | 6.58 | 7.66 | 8.67 | 10.1 | 12.9 | 15.5 |
| 1000 | 1.05 | 1.59 | 1.97 | 2.65 | 3.28 | 3.49 | 3.5 | 3.72 | 3.94 | 4.64 | 5.27 | 6.26 | 7.18 | 8.41 | 9.36 | 10.8 | 13.9 | 16.8 |

Rainfall Depth (in)

Table III.B.2
3 HR STORM

| Time | Inches (incremental) | * Inches (cumulative) | Difference | Distributed | Cumulative | Percentage |
|---|---|---|---|---|---|---|
| 0 | 0.0000 | 0.00 | 0.000 | 0.000 | 0.000 | 0.00 |
| 15 | 0.0407 | 0.61 | 0.610 | 0.020 | 0.020 | 1.72 |
| 30 | 0.0277 | 0.83 | 0.220 | 0.020 | 0.040 | 3.45 |
| 45 | 0.0211 | 0.95 | 0.120 | 0.020 | 0.060 | 5.17 |
| 60 | 0.0170 | 1.02 | 0.070 | 0.050 | 0.110 | 9.48 |
| 75 | 0.0143 | 1.07 | 0.050 | 0.120 | 0.230 | 19.83 |
| 90 | 0.0122 | 1.10 | 0.030 | 0.610 | 0.840 | 72.41 |
| 105 | 0.0107 | 1.12 | 0.020 | 0.220 | 1.060 | 91.38 |
| 120 | 0.0095 | 1.14 | 0.020 | 0.070 | 1.130 | 97.41 |
| 135 | 0.0086 | 1.16 | 0.020 | 0.030 | 1.160 | 100.00 |
| 150 | 0.0079 | 1.18 | 0.020 | 0.020 | 1.180 | 101.72 |
| 165 | 0.0073 | 1.20 | 0.020 | 0.020 | 1.200 | 103.45 |
| 180 | 0.0068 | 1.22 | 0.020 | 0.020 | 1.220 | 105.17 |

* Taken from the NOAA Atlas 14 data and interpolated for unknown points.

| | |
|---|---|
| (green) | Actual data from Atlas 14 |
| (orange) | Interpolated data from Atlas 14 |

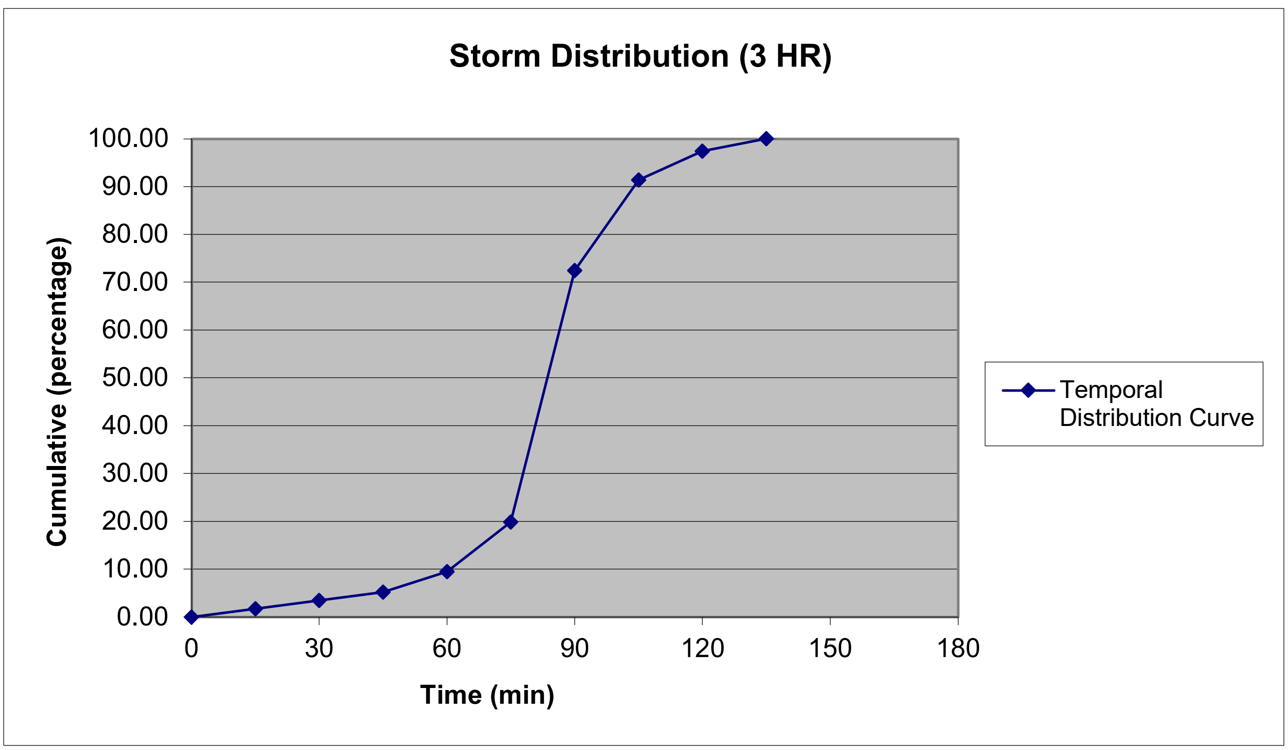

Table III.B.3

| | | 3 HR 10 YR EXISTING CONDITIONS | | | | | 3 HR 100 YR EXISTING CONDITIONS | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Basin** | **Area (acres)** | **CN** | **Lag Time (hrs)** | **Peak Flow (cfs)** | **Time to Peak (min)** | **Total Volume (ft^3)** | **CN** | **Lag Time (hrs)** | **Peak Flow (cfs)** | **Time to Peak (min)** | **Total Volume (ft^3)** |
| 1 | 693.376 | 75.22 | 0.2906 | 35 | 90 | 176,187 | 75.22 | 0.2906 | 362.2 | 75 | 1,031,952 |
| 2 | 17.344 | 73.15 | 0.0668 | 0.7 | 75 | 3,148 | 73.15 | 0.0668 | 10.1 | 60 | 21,406 |
| 3 | 47.68 | 75.94 | 0.1067 | 3.6 | 75 | 13,846 | 75.94 | 0.1067 | 37.1 | 60 | 74,424 |
| 4 | 131.264 | 75.93 | 0.2219 | 8.8 | 75 | 38,119 | 75.93 | 0.2219 | 76.4 | 75 | 204,890 |
| 5 | 19.648 | 70.06 | 0.0349 | 0.3 | 75 | 1,426 | 70.06 | 0.0349 | 7.9 | 60 | 18,544 |
| 6 | 80.064 | 62.58 | 0.1373 | 0 | 0 | 0 | 62.58 | 0.1373 | 10.9 | 75 | 31,970 |
| 7 | 557.696 | 77.66 | 0.2579 | 50.2 | 75 | 202,444 | 77.66 | 0.2579 | 372.5 | 75 | 1,012,218 |
| 8 | 110.784 | 73.34 | 0.2024 | 4.1 | 75 | 20,107 | 73.34 | 0.2024 | 50.8 | 75 | 140,751 |
| 9 | 17.6 | 67.38 | 0.0384 | 0.1 | 120 | 639 | 67.38 | 0.0384 | 4.8 | 60 | 12,778 |
| 10 | 22.08 | 62.23 | 0.0426 | 0 | 0 | 0 | 62.23 | 0.0426 | 2.9 | 75 | 8,015 |
| 11 | 36.224 | 63 | 0.1225 | 0 | 180 | 0 | 63 | 0.1225 | 5.3 | 75 | 14,464 |
| 12 | 148.16 | 75.51 | 0.123 | 10.3 | 75 | 37,647 | 75.51 | 0.123 | 110.4 | 60 | 225,885 |
| 13 | 16.192 | 57.67 | 0.0757 | 0 | 0 | 0 | 57.67 | 0.0757 | 0.9 | 75 | 2,351 |
| 14 | 64.768 | 75.63 | 0.085 | 4.6 | 75 | 18,809 | 75.63 | 0.085 | 48.8 | 60 | 98,745 |
| 15 | 31.936 | 66.75 | 0.0802 | 0.1 | 180 | 1,159 | 66.75 | 0.0802 | 7.9 | 60 | 20,867 |
| 16 | 404.352 | 77.05 | 0.2816 | 30.7 | 75 | 132,102 | 77.05 | 0.2816 | 251.2 | 75 | 689,865 |
| 17 | 56.896 | 65.4 | 0.1374 | 0.1 | 180 | 0 | 65.4 | 0.1374 | 11.2 | 75 | 30,980 |
| 18 | 14.4 | 61.94 | 0.1345 | 0 | 0 | 0 | 61.94 | 0.1345 | 1.8 | 75 | 5,227 |
| 19 | 86.912 | 76.83 | 0.1644 | 7.4 | 75 | 28,394 | 76.83 | 0.1644 | 62.2 | 60 | 148,281 |
| 20 | 62.336 | 70.44 | 0.1972 | 1 | 90 | 6,788 | 70.44 | 0.1972 | 21.5 | 75 | 61,096 |
| 21 | 243.776 | 73.19 | 0.1843 | 9 | 75 | 44,245 | 73.19 | 0.1843 | 108.1 | 75 | 309,717 |
| 22 | 64.704 | 64.99 | 0.172 | 0.1 | 180 | 0 | 64.99 | 0.172 | 11.9 | 75 | 35,231 |
| 23 | 23.68 | 62.66 | 0.1446 | 0 | 0 | 0 | 62.66 | 0.1446 | 3.2 | 75 | 9,455 |
| 24 | 73.728 | 76.41 | 0.0973 | 6 | 75 | 24,087 | 76.41 | 0.0973 | 60 | 60 | 120,435 |
| 25 | 84.352 | 66.97 | 0.2045 | 0.4 | 180 | 3,062 | 66.97 | 0.2045 | 19.8 | 75 | 58,178 |
| 26 | 280.64 | 77 | 0.235 | 23 | 75 | 91,685 | 77 | 0.235 | 179 | 75 | 478,800 |
| 27 | 53.376 | 77 | 0.1592 | 4.7 | 75 | 17,438 | 77 | 0.1592 | 39.8 | 60 | 91,065 |
| 28 | 39.36 | 70.21 | 0.131 | 0.6 | 75 | 2,858 | 70.21 | 0.131 | 15.7 | 60 | 37,148 |
| 29 | 50.496 | 73.75 | 0.1715 | 2.2 | 75 | 9,165 | 73.75 | 0.1715 | 25.5 | 60 | 65,988 |
| 30 | 36.544 | 63.28 | 0.0897 | 0 | 180 | 0 | 63.28 | 0.0897 | 5.6 | 75 | 15,919 |
| 31 | 82.432 | 57.99 | 0.162 | 0 | 0 | 0 | 57.99 | 0.162 | 4.5 | 75 | 14,961 |
| 32 | 208.192 | 64.74 | 0.2507 | 0.3 | 180 | 0 | 64.74 | 0.2507 | 34.2 | 75 | 105,803 |
| 33 | 24.576 | 56.31 | 0.1012 | 0 | 0 | 0 | 56.31 | 0.1012 | 0.9 | 75 | 2,676 |
| 34 | 195.072 | 77 | 0.2489 | 15.6 | 75 | 63,730 | 77 | 0.2489 | 123.9 | 75 | 332,812 |
| 35 | 197.568 | 77 | 0.3514 | 13.7 | 90 | 64,545 | 77 | 0.3514 | 107.6 | 75 | 337,071 |
| 36 | 567.424 | 77 | 0.4576 | 36.4 | 90 | 185,377 | 77 | 0.4576 | 266.3 | 90 | 968,082 |
| 37 | 257.408 | 65.39 | 0.2697 | 0.6 | 180 | 0 | 65.39 | 0.2697 | 45.1 | 75 | 140,159 |

Table III.B.4

| | | 3 HR 10 YR FUTURE CONDITIONS | | | | | 3 HR 100 YR FUTURE CONDITIONS | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Basin** | **Area (acres)** | **CN** | **Lag Time (hrs)** | **Peak Flow (cfs)** | **Time to Peak (min)** | **Total Volume (ft^3)** | **CN** | **Lag Time (hrs)** | **Peak Flow (cfs)** | **Time to Peak (min)** | **Total Volume (ft^3)** |
| 1 | 693.376 | 75.22 | 0.2906 | 35 | 90 | 176,187 | 75.22 | 0.2906 | 362.2 | 75 | 1,031,952 |
| 2 | 17.344 | 73.15 | 0.0668 | 0.7 | 75 | 3,148 | 73.15 | 0.0668 | 10.1 | 60 | 21,406 |
| 3 | 47.68 | 75.94 | 0.1067 | 3.6 | 75 | 13,846 | 75.94 | 0.1067 | 37.1 | 60 | 74,424 |
| 4 | 131.264 | 75.93 | 0.2219 | 8.8 | 75 | 38,119 | 75.93 | 0.2219 | 76.4 | 75 | 204,890 |
| 5 | 19.648 | 70.06 | 0.0349 | 0.3 | 75 | 1,426 | 70.06 | 0.0349 | 7.9 | 60 | 18,544 |
| 6 | 80.064 | 72.9 | 0.1373 | 3.1 | 75 | 14,532 | 72.9 | 0.1373 | 43 | 60 | 98,815 |
| 7 | 557.696 | 78.8 | 0.2579 | 62.3 | 75 | 242,932 | 78.8 | 0.2579 | 408.8 | 75 | 1,093,196 |
| 8 | 110.784 | 73.7 | 0.2024 | 4.5 | 75 | 20,107 | 73.7 | 0.2024 | 52.5 | 75 | 144,773 |
| 9 | 17.6 | 67.38 | 0.0384 | 0.1 | 120 | 639 | 67.38 | 0.0384 | 4.8 | 60 | 12,778 |
| 10 | 22.08 | 62.23 | 0.0426 | 0 | 0 | 0 | 62.23 | 0.0426 | 2.9 | 75 | 8,015 |
| 11 | 36.224 | 71.4 | 0.1225 | 0.9 | 75 | 3,945 | 71.4 | 0.1225 | 17.1 | 60 | 38,133 |
| 12 | 148.16 | 77.2 | 0.123 | 13.8 | 75 | 53,782 | 77.2 | 0.123 | 130.2 | 60 | 258,154 |
| 13 | 16.192 | 57.67 | 0.0757 | 0 | 0 | 0 | 57.67 | 0.0757 | 0.9 | 75 | 2,351 |
| 14 | 64.768 | 78.2 | 0.085 | 7.2 | 60 | 25,862 | 78.2 | 0.085 | 62.5 | 60 | 122,256 |
| 15 | 31.936 | 70.6 | 0.0802 | 0.6 | 75 | 3,478 | 70.6 | 0.0802 | 13.7 | 60 | 31,300 |
| 16 | 404.352 | 78.6 | 0.2816 | 41.8 | 75 | 176,136 | 78.6 | 0.2816 | 286 | 75 | 777,933 |
| 17 | 56.896 | 76.4 | 0.1374 | 4.6 | 75 | 18,588 | 76.4 | 0.1374 | 44.1 | 60 | 92,940 |
| 18 | 14.4 | 61.94 | 0.1345 | 0 | 0 | 0 | 61.94 | 0.1345 | 1.8 | 75 | 5,227 |
| 19 | 86.912 | 77.6 | 0.1644 | 8.5 | 75 | 31,549 | 77.6 | 0.1644 | 66.9 | 60 | 154,590 |
| 20 | 62.336 | 73.5 | 0.1972 | 2.4 | 75 | 11,314 | 73.5 | 0.1972 | 28.9 | 75 | 79,198 |
| 21 | 243.776 | 75.3 | 0.1843 | 15.1 | 75 | 61,943 | 75.3 | 0.1843 | 134.3 | 60 | 362,812 |
| 22 | 64.704 | 68.1 | 0.172 | 0.4 | 120 | 2,349 | 68.1 | 0.172 | 17.3 | 75 | 49,324 |
| 23 | 23.68 | 63.2 | 0.1446 | 0 | 180 | 0 | 63.2 | 0.1446 | 3.5 | 75 | 10,315 |
| 24 | 73.728 | 78 | 0.0973 | 7.8 | 60 | 29,440 | 78 | 0.0973 | 69.8 | 60 | 136,493 |
| 25 | 84.352 | 70.1 | 0.2045 | 1.2 | 90 | 6,124 | 70.1 | 0.2045 | 28.2 | 75 | 79,611 |
| 26 | 280.64 | 79 | 0.235 | 33.4 | 75 | 132,434 | 79 | 0.235 | 210.4 | 75 | 560,298 |
| 27 | 53.376 | 79 | 0.1592 | 6.5 | 75 | 25,188 | 79 | 0.1592 | 47.8 | 60 | 106,565 |
| 28 | 39.36 | 70.21 | 0.131 | 0.6 | 75 | 2,858 | 70.21 | 0.131 | 15.7 | 60 | 37,148 |
| 29 | 50.496 | 73.75 | 0.1715 | 2.2 | 75 | 9,165 | 73.75 | 0.1715 | 25.5 | 60 | 65,988 |
| 30 | 36.544 | 63.28 | 0.0897 | 0 | 180 | 0 | 63.28 | 0.0897 | 5.6 | 75 | 15,919 |
| 31 | 82.432 | 57.99 | 0.162 | 0 | 0 | 0 | 57.99 | 0.162 | 4.5 | 75 | 14,961 |
| 32 | 208.192 | 68.1 | 0.2507 | 1.3 | 135 | 7,557 | 68.1 | 0.2507 | 54.1 | 75 | 158,705 |
| 33 | 24.576 | 56.31 | 0.1012 | 0 | 0 | 0 | | | 0.9 | 75 | 2,676 |
| 34 | 195.072 | 78.9 | 0.2489 | 22.5 | 75 | 84,973 | 78.9 | 0.2489 | 144.7 | 75 | 382,380 |
| 35 | 197.568 | 79 | 0.3514 | 19.1 | 90 | 93,232 | 79 | 0.3514 | 127.7 | 75 | 394,445 |
| 36 | 567.424 | 79.3 | 0.4576 | 54.8 | 90 | 267,767 | 79.3 | 0.4576 | 319.3 | 90 | 1,153,460 |
| 37 | 257.408 | 67.5 | 0.2697 | 1.3 | 135 | 9,344 | 67.5 | 0.2697 | 60.4 | 75 | 186,878 |

Table V.A.1 - Engineer's Opinion of Probable Cost

| Improvement Item (See System Inventory List in Chapter 4) | | | | Phase Assignment |
|---|---|---|---|---|
| ITEM | UNIT | $/UNIT | QUANTITY | PRICE ($) |

| System Inventory List - Curb and Gutter Foothill Drive (#1) | | | | |
|---|---|---|---|---|
| Mobilization | LS | 8% | 1 | $ 10,000.00 |
| Traffic Control | LS | $ 5,000.00 | 1 | $ 5,000.00 |
| SWPPP | LS | $ 2,000.00 | 1 | $ 2,000.00 |
| Modified Curb and Gutter | LF | $ 30.00 | 850 | $ 25,500.00 |
| Sidewalk | LF | $ 8.00 | 400 | $ 3,200.00 |
| 12" Subbase Course | SF | $ 2.00 | 9500 | $ 19,000.00 |
| Asphalt Removal and Replacement | SF | $ 6.10 | 9500 | $ 58,000.00 |
| Raise and Lower Utilities | LS | $ 9,000.00 | 1 | $ 9,000.00 |
| Construction Miscellaneous Items | LS | 15% | 1 | $ 18,255.00 |
| | | | | |
| **Sub-Total** | | | | $ 150,000.00 |
| **Incidentals** | | | | $ 45,000.00 |
| **Construction Contingency** | LS | 15% | 1 | $ 23,000.00 |
| **Total Construction** | | | | $ 218,000.00 |
| | | | | |
| **GRAND TOTAL** | | | | **$ 218,000.00** |

*In providing opinions of probable construction cost, the Client understands that the Engineer has no control over costs or the price of labor, equipment or materials, or over the Contractor's method of pricing, and that the opinion of probable construction cost provided herein is made on the basis of the Engineer's qualifications and experience. The Engineer makes no warranty, expressed or implied, as to the accuracy of such opinions compared to bid or actual costs.*

| System Inventory List - Curb and Gutter by Church (#2) | | | | |
|---|---|---|---|---|
| Mobilization | LS | 8% | 1 | $ 3,000.00 |
| Traffic Control | LS | $ 7,000.00 | 1 | $ 7,000.00 |
| Earthwork/Grading | SF | $ 4.00 | 1000 | $ 4,000.00 |
| Standard Curb and Gutter | LF | $ 33.00 | 600 | $ 20,000.00 |
| Curb Inlet Modification | EA | $ 2,600.00 | 1 | $ 2,600.00 |
| 12" Subbase Course | SF | $ 2.00 | 1800 | $ 3,600.00 |
| Construction Miscellaneous Items | LS | 15% | 1 | $ 4,000.00 |
| | | | | |
| **Sub-Total** | | | | $ 44,000.00 |
| **Incidentals** | | | | $ 13,200.00 |
| **Construction Contingency** | LS | 15% | 1 | $ 6,600.00 |
| **Total Construction** | | | | $ 63,800.00 |
| | | | | |
| **GRAND TOTAL** | | | | **$ 63,800.00** |

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| Improvement Item (See System Inventory List in Chapter 4) | | | | Phase Assignment |
|---|---|---|---|---|
| ITEM | UNIT | $/UNIT | QUANTITY | PRICE ($) |

| System Inventory List - Construct Conveyance Facility for Irrigation Ditch near Claret Cup (#3) | | | | |
|---|---|---|---|---|
| Mobilization | LS | 8% | 1 | $ 13,000.00 |
| Catch Basin w/ Grate | EA | $ 2,600.00 | 3 | $ 7,800.00 |
| Outlet Structure | EA | $ 5,500.00 | 1 | $ 5,500.00 |
| 18-inch Class III RCP (installed) | LF | $ 80.00 | 1600 | $ 128,000.00 |
| Asphalt Removal and Replacement | SF | $ 5.75 | 600 | $ 3,450.00 |
| Construction Miscellaneous Items | LS | 15% | 1 | $ 22,000.00 |
| | | | | |
| **Sub-Total** | | | | $ 180,000.00 |
| **Incidentals** | | | | $ 54,000.00 |
| **Construction Contingency** | LS | 15% | 1 | $ 27,000.00 |
| **Total Construction** | | | | $ 261,000.00 |
| | | | | |
| **GRAND TOTAL** | | | | **$ 261,000.00** |

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| System Inventory List - Improve Swale north of Majestic View Lodge (#4) | | | | |
|---|---|---|---|---|
| Mobilization | LS | 8% | 1 | $ 1,000.00 |
| Traffic Control | LS | $ 6,000.00 | 1 | $ 6,000.00 |
| Earthwork/Grading | SF | $ 4.00 | 1200 | $ 4,800.00 |
| Standard Curb and Gutter | LF | $ 45.00 | 150 | $ 6,750.00 |
| 12" Subbase Course | SF | $ 2.00 | 450 | $ 900.00 |
| Construction Miscellaneous Items | LS | 15% | 1 | $ 720.00 |
| | | | | |
| **Sub-Total** | | | | $ 20,000.00 |
| **Incidentals** | | | | $ 6,000.00 |
| **Construction Contingency** | LS | 15% | 1 | $ 3,000.00 |
| **Total Construction** | | | | $ 29,000.00 |
| | | | | |
| **GRAND TOTAL** | | | | **$ 29,000.00** |

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| Improvement Item (See System Inventory List in Chapter 4) | | | | Phase Assignment |
|---|---|---|---|---|
| ITEM | UNIT | $/UNIT | QUANTITY | PRICE ($) |

| System Inventory List - Install Elm St Hydromarine Separator (#5) | | | | |
|---|---|---|---|---|
| Mobilization | LS | 8% | 1 | $ 1,700.00 |
| Storm Sump Separator | LS | $ 20,000.00 | 1 | $ 20,000.00 |
| Misc. Connections & Fittings | LS | $ 800.00 | 1 | $ 800.00 |
| Restore Surface Improvements | LS | $ 1,250.00 | 1 | $ 1,250.00 |
| | | | | |
| **Sub-Total** | | | | $ 24,000.00 |
| **Incidentals** | | | | $ 7,200.00 |
| **Construction Contingency** | LS | 15% | 1 | $ 4,000.00 |
| **Total Construction** | | | | $ 35,200.00 |
| | | | | |
| **GRAND TOTAL** | | | | **$ 35,200.00** |

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| System Inventory List - Transition Between SR-9 & Paved Trail (#6) | | | | |
|---|---|---|---|---|
| Mobilization | LS | 8% | 1 | $ 6,000.00 |
| Traffic Control | LS | $ 8,000.00 | 1 | $ 8,000.00 |
| Top Soil/Cobbles & Natural Vegitation | SF | $ 2.00 | 30900 | $ 61,800.00 |
| Restore Surface Improvements | LS | $ 15,000.00 | 1 | $ 15,000.00 |
| | | | | |
| **Sub-Total** | | | | $ 91,000.00 |
| **Incidentals** | | | | $ 27,300.00 |
| **Construction Contingency** | LS | 15% | 1 | $ 14,000.00 |
| **Total Construction** | | | | $ 132,300.00 |
| | | | | |
| **GRAND TOTAL** | | | | **$ 132,300.00** |

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| Improvement Item (See System Inventory List in Chapter 4) | | | | Phase Assignment |
|---|---|---|---|---|
| ITEM | UNIT | $/UNIT | QUANTITY | PRICE ($) |

| System Inventory List - Gravel Conveyance Ditch (#7) | | | | |
|---|---|---|---|---|
| Mobilization | LS | 8% | 1 | $ 345.00 |
| Earthwork & Grading | LS | $ 2,700.00 | 1 | $ 2,700.00 |
| Gravel Ditch | LS | $ 1,900.00 | 1 | $ 1,900.00 |
| | | | | |
| **Sub-Total** | | | | $ 4,900.00 |
| **Incidentals** | | | | $ 1,500.00 |
| **Construction Contingency** | LS | 15% | 1 | $ 700.00 |
| **Total Construction** | | | | $ 7,100.00 |
| | | | | |
| **GRAND TOTAL** | | | | **$ 7,100.00** |

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| System Inventory List - Maintenance Shed Road Chip Seal & Culverts (#10) | | | | |
|---|---|---|---|---|
| Mobilization | LS | 8% | 1 | $ 2,400.00 |
| Earthwork & Grading | LS | $ 20,000.00 | 1 | $ 20,000.00 |
| Double Chip Seal | SY | $ 5.00 | 820 | $ 4,100.00 |
| Culverts | LF | $ 100.00 | 80 | $ 8,000.00 |
| | | | | |
| **Sub-Total** | | | | $ 34,500.00 |
| **Incidentals** | | | | $ 10,400.00 |
| **Construction Contingency** | LS | 15% | 1 | $ 5,200.00 |
| **Total Construction** | | | | $ 50,100.00 |
| | | | | |
| **GRAND TOTAL** | | | | **$ 50,100.00** |

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| Improvement Item (See System Inventory List in Chapter 4) | | | | Phase Assignment |
|---|---|---|---|---|
| ITEM | UNIT | $/UNIT | QUANTITY | PRICE ($) |

| System Inventory List - Big Springs Rd. Improvements (#12) | | | | |
|---|---|---|---|---|
| Mobilization | LS | 8% | 1 | $ 14,500.00 |
| Pre-Construction DVD | EA | $ 1,000.00 | 1 | $ 1,000.00 |
| Traffic Control | LS | $ 9,000.00 | 1 | $ 9,000.00 |
| Subsurface Investigation | HR | $ 275.00 | 10 | $ 2,750.00 |
| Dust Control & Watering | LS | $ 5,000.00 | 1 | $ 5,000.00 |
| Erosion Control Compliance | LS | $ 5,000.00 | 1 | $ 5,000.00 |
| Roadway Excavation and Removal | SF | $ 1.80 | 17,000 | $ 30,600.00 |
| Sub Base Course (Assumed 10") | SF | $ 1.80 | 17,000 | $ 30,600.00 |
| Untreated Base Course (Assumed 6") | SF | $ 1.30 | 17,000 | $ 22,100.00 |
| Bitumunous Surface Course (Assumed 3"Category I) | SF | $ 3.50 | 17,000 | $ 59,500.00 |
| Raise and Lower Utilties | LS | $ 8,000.00 | 1 | $ 8,000.00 |
| Concrete Collars for Manholes and Valves | LS | $ 8,000.00 | 1 | $ 8,000.00 |
| | | | | |
| **Sub-Total** | | | | $ 196,000.00 |
| **Incidentals** | | | | $ 58,800.00 |
| **Construction Contingency** | LS | 15% | 1 | $ 29,400.00 |
| **Total Construction** | | | | $ 284,200.00 |
| | | | | |
| **GRAND TOTAL** | | | | **$ 284,200.00** |

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| Improvement Item (See System Inventory List in Chapter 4) | | | | Phase Assignment |
|---|---|---|---|---|
| ITEM | UNIT | $/UNIT | QUANTITY | PRICE ($) |

| System Inventory List - Hummingbird Rd. Improvements (#13) | | | | |
|---|---|---|---|---|
| Mobilization | LS | 8% | 1 | $ 17,500.00 |
| Pre-Construction DVD | EA | $ 1,000.00 | 1 | $ 1,000.00 |
| Traffic Control | LS | $ 3,000.00 | 1 | $ 3,000.00 |
| Subsurface Investigation | HR | $ 300.00 | 10 | $ 3,000.00 |
| Dust Control & Watering | LS | $ 1,500.00 | 1 | $ 1,500.00 |
| Erosion Control Compliance | LS | $ 1,500.00 | 1 | $ 1,500.00 |
| Clearing and Grubbing, Saw Cutting, Demoliton | LS | $ 1,500.00 | 1 | $ 1,500.00 |
| Roadway Excavation and Removal | SF | $ 1.80 | 12,500 | $ 22,500.00 |
| Sub Base Course (Assumed 10") | SF | $ 1.80 | 12,500 | $ 22,500.00 |
| Untreated Base Course (Assumed 6") | SF | $ 1.30 | 12,500 | $ 16,250.00 |
| Bitumunous Surface Course (Assumed 3"Category I) | SF | $ 3.50 | 12,500 | $ 43,750.00 |
| Modified Concrete Curb and Gutter | LF | $ 30.00 | 1,050 | $ 31,500.00 |
| Msic. SD Connections and Tie-Ins | LS | $ 2,500.00 | 1 | $ 2,500.00 |
| Concrete Catch Basin | EA | $ 4,750.00 | 3 | $ 14,250.00 |
| 15" HDPE | LF | $ 85.00 | 500 | $ 42,500.00 |
| Construct Concrete Collars for Manholes and Valves | LS | $ 2,000.00 | 1 | $ 2,000.00 |
| Relocated Existing Fire Hydrant | EA | $ 3,500.00 | 1 | $ 3,500.00 |
| Expansive Clay Mitigation | CY | $ 45.00 | 140 | $ 6,300.00 |
| | | | | |
| **Sub-Total** | | | | $ 237,000.00 |
| **Incidentals** | | | | $ 71,100.00 |
| **Construction Contingency** | LS | 15% | 1 | $ 35,600.00 |
| **Total Construction** | | | | $ 343,700.00 |
| | | | | |
| **GRAND TOTAL** | | | | **$ 343,700.00** |

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| Improvement Item (See System Inventory List in Chapter 4) | | | | Phase Assignment | |
|---|---|---|---|---|---|
| ITEM | UNIT | $/UNIT | QUANTITY | PRICE ($) | |
| **System Inventory List - Balanced Rock Rd. Improvements (#14)** | | | | | |
| Mobilization | LS | 8% | 1 | $ | 41,800.00 |
| Pre-Construction DVD | EA | $ 1,000.00 | 1 | $ | 1,000.00 |
| Traffic Control | LS | $ 6,000.00 | 1 | $ | 6,000.00 |
| Subsurface Investigation | HR | $ 300.00 | 10 | $ | 3,000.00 |
| Dust Control & Watering | LS | $ 3,500.00 | 1 | $ | 3,500.00 |
| Erosion Control Compliance | LS | $ 3,500.00 | 1 | $ | 3,500.00 |
| Slope Stabilization (Overexcavation and Retaining Wall) | LS | $ 300,000.00 | 1 | $ | 300,000.00 |
| Clearing and Grubbing, Saw Cutting, Demoliton | LS | $ 2,500.00 | 1 | $ | 2,500.00 |
| Roadway Excavation and Removal | SF | $ 1.80 | 8,050 | $ | 14,490.00 |
| Sub Base Course (Assumed 10") | SF | $ 1.80 | 8,050 | $ | 14,490.00 |
| Untreated Base Course (Assumed 6") | SF | $ 1.30 | 8,050 | $ | 10,465.00 |
| Bitumunous Surface Course (Assumed 3"Category I) | SF | $ 3.50 | 8,050 | $ | 28,175.00 |
| Standard Concrete Curb and Gutter | LF | $ 33.00 | 700 | $ | 23,100.00 |
| Concrete Driveway Approach | SF | $ 15.00 | 225 | $ | 3,375.00 |
| Msic. SD Connections and Tie-Ins | LS | $ 2,500.00 | 1 | $ | 2,500.00 |
| Concrete Double Catch Basin | EA | $ 7,000.00 | 1 | $ | 7,000.00 |
| 15" HDPE | LF | $ 85.00 | 50 | $ | 4,250.00 |
| Construct Concrete Collars for Manholes and Valves | LS | $ 750.00 | 1 | $ | 750.00 |
| 6" PVC C900 | LF | $ 60.00 | 710 | $ | 42,600.00 |
| 6" Gate Valve Assembly | EA | $ 2,500.00 | 2 | $ | 5,000.00 |
| Expansive Clay Mitigation | CY | $ 45.00 | 1,040 | $ | 46,800.00 |
| Roadway Signs | EA | $ 150.00 | 4 | $ | 600.00 |
| | | | | | |
| **Sub-Total** | | | | $ | 565,000.00 |
| **Incidentals** | | | | $ | 169,500.00 |
| **Construction Contingency** | LS | 15% | 1 | $ | 84,800.00 |
| **Total Construction** | | | | $ | 819,300.00 |
| | | | | | |
| **GRAND TOTAL** | | | | **$** | **819,300.00** |

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| Improvement Item (See System Inventory List in Chapter 4) | | | | Phase Assignment |
|---|---|---|---|---|
| ITEM | UNIT | $/UNIT | QUANTITY | PRICE ($) |
| **System Inventory List - Lion Boulevard Improvements (#15)** | | | | |
| Mobilization | LS | 8% | 1 | $ 22,000.00 |
| Traffic Control | LS | $ 13,000.00 | 1 | $ 13,000.00 |
| SWPPP | LS | $ 5,000.00 | 1 | $ 5,000.00 |
| Catch Basin w/ Grate | EA | $ 2,600.00 | 4 | $ 10,400.00 |
| Standard Concrete Curb and Gutter | LF | $ 33.00 | 2,250 | $ 74,250.00 |
| Sidewalk | LF | $ 8.00 | 900 | $ 7,200.00 |
| 12" Subbase Course | SF | $ 2.00 | 9,500 | $ 19,000.00 |
| Asphalt Removal and Replacement | SF | $ 5.75 | 9,500 | $ 55,000.00 |
| Raise and Lower Utilities | LS | $ 24,000.00 | 1 | $ 24,000.00 |
| Construction Miscellaneous Items | LS | 15% | 1 | $ 31,177.50 |
| 24" HDPE | LF | $ 115.00 | 450 | $ 52,000.00 |
| Cross Gutter | LF | $ 40.00 | 50 | $ 2,000.00 |
| | | | | |
| **Sub-Total** | | | | $ 315,000.00 |
| **Incidentals** | | | | $ 94,500.00 |
| **Construction Contingency** | LS | 15% | 1 | $ 47,300.00 |
| **Total Construction** | | | | $ 456,800.00 |
| | | | | |
| **GRAND TOTAL** | | | | **$ 456,800.00** |

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| | |
|---|---|
| **PROJECTS TOTAL** | **$ 2,700,500.00** |

# APPENDIX C – HYDROLOGIC EVALUATION RESOURCES

# NATURAL DRAINAGE CHANNEL PEAK FLOW AND CAPACITY CALCULATIONS FOR **EXISTING** CONDITIONS

Constant n-value 0.05

| | | Existing Hydrologic Conditions | | | | Wash Characteristics | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Drainage Sub-basin | Natural Drainage Wash Responsible for the Drainage of the specified Sub-basin | 10 Year Peak Flows (cfs) | 100 Year Peak Flows (cfs) | Design Flow for Wash at 10 Year Combined Peak Flows (cfs) | Design Flow for Wash at 100 Year Combined Peak Flows (cfs) | Upper Channel Elevation (ft) | Lower Channel Elevation (ft) | Channel Length (ft) | Slope (ft/ft) | Percent Slope (%) | Bottom Width (ft) | Side Slope (run/1) (ft) | Depth (ft) | n-value | Capacity of Channel Q (cfs) | EXISTING Percent Full Under Peak Flow 100 YEAR |
| 1 | Visitors Center Wash | 35.0 | 362.2 | | | | | | | | | | | | | |
| 2 | Park Entrance Wash | 0.7 | 10.1 | | | | | | | | | | | | | |
| 3 | Park Entrance Wash | 3.6 | 37.1 | | | | | | | | | | | | | |
| 4 | Park Entrance Wash | 8.8 | 76.4 | | | | | | | | | | | | | |
| 5 | Coffee Shop Wash | 0.3 | 7.9 | | | | | | | | | | | | | |
| 6 | Watchman Campground Wash | 0.0 | 10.9 | | | | | | | | | | | | | |
| 7 | Blacks Canyon Wash | 50.2 | 373 | 114 | 585 | 4,660 | 3,873 | 8,286 | 0.095 | 9.5% | 5 | 1 | 5 | 0.05 | 871 | 67% |
| 8 | Blacks Canyon Wash | 4.1 | 51 | | | | | | | | | | | | | |
| 9 | Zion Canyon Campgound Wash | 0.1 | 5 | | | | | | | | | | | | | |
| 10 | Zion Canyon Campgound Wash | 0.0 | 3 | | | | | | | | | | | | | |
| 11 | La Quinta Wash | 0.0 | 5.3 | | | | | | | | | | | | | |
| 12 | Desert Pearl Inn Wash | 10.3 | 110 | 27 | 155 | 4,081 | 3,846 | 1,976 | 0.119 | 11.9% | 3 | 1 | 4 | 0.05 | 450 | 34% |
| 13 | Desert Pearl Inn Wash | 0.0 | 1 | | | | | | | | | | | | | |
| 14 | Canyon Springs Dr Wash | 4.6 | 49 | 14 | 76 | 4,160 | 3,834 | 2,117 | 0.154 | 15.4% | 2 | 1 | 3 | 0.05 | 223 | 34% |
| 15 | Canyon Springs Dr Wash | 0.1 | 8 | | | | | | | | | | | | | |
| 16 | Springdale Wash | 30.7 | 251 | 74 | 350 | 4,150 | 3,841 | 5,666 | 0.055 | 5.5% | 6 | 1 | 8 | 0.05 | 1,935 | 18% |
| 17 | Springdale Wash | 0.1 | 11 | | | | | | | | | | | | | |
| 18 | Springdale Wash | 0.0 | 2 | | | | | | | | | | | | | |
| 19 | Gifford Park Ln Wash | 7.4 | 62 | 19 | 140 | 4,005 | 3,834 | 2,904 | 0.059 | 5.9% | 6 | 1 | 4 | 0.05 | 506 | 28% |
| 20 | Gifford Park Ln Wash | 1.0 | 22 | | | | | | | | | | | | | |
| 21 | Canyon Cove Circle Wash | 9.0 | 108 | 26 | 174 | 3,963 | 3,833 | 2,311 | 0.056 | 5.6% | 8 | 1 | 5 | 0.05 | 942 | 18% |
| 22 | River Bend Circle Wash | 0.1 | 12 | | | | | | | | | | | | | |
| 23 | Claret Cup East Wash | 0.0 | 3.2 | | | | | | | | | | | | | |
| 24 | Claret Cup Wash | 6.0 | 60 | 20 | 95 | 4,163 | 3,825 | 3,099 | 0.109 | 10.9% | 3 | 1 | 4 | 0.05 | 431 | 22% |
| 25 | Claret Cup Wash | 0.4 | 20 | | | | | | | | | | | | | |
| 26 | Serendipity Ln Wash | 23.0 | 179 | 60 | 270 | 3,939 | 3,802 | 2,803 | 0.049 | 4.9% | 6 | 1 | 5 | 0.05 | 708 | 38% |
| 27 | Serendipity Ln Wash | 4.7 | 40 | | | | | | | | | | | | | |
| 28 | Serendipity Ln Wash | 0.6 | 16 | | | | | | | | | | | | | |
| 29 | Serendipity Ln Wash West | 2.2 | 26 | | | | | | | | | | | | | |
| 30 | Dixie Ln Wash | 0.0 | 6 | | | | | | | | | | | | | |
| 31 | Valley View Dr Wash | 0.0 | 5 | 0 | 5 | 3,932 | 3,825 | 1,557 | 0.069 | 6.9% | 2 | 1 | 3 | 0.05 | 149 | 3% |
| 32 | North Fork Dr Wash | 0.3 | 34 | 0 | 62 | 3,904 | 3,806 | 2,329 | 0.042 | 4.2% | | 1 | | | | |
| 33 | River Confluence Wash | 0.0 | 1 | | | | | | | | | | | | | |
| 34 | East Anasazi Wash | 15.6 | 124 | 34 | 165 | 4,108 | 3,890 | 4,366 | 0.050 | 5.0% | 20 | 1 | 6 | 0.05 | 2,713 | 6% |
| 35 | West Anasazi Wash | 13.7 | 108 | 110 | 490 | 4,071 | 3,926 | 5,662 | 0.026 | 2.6% | 20 | 1 | 9 | 0.05 | 3,991 | 12% |
| 36 | West Anasazi Wash | 36.4 | 266 | | | | | | | | | | | | | |
| 37 | East and West Anasazi Wash | 0.6 | 45 | 143 | 715 | 4,071 | 3,926 | 5,662 | 0.026 | 2.6% | 20 | 1 | 9 | 0.05 | 3,991 | 18% |

# NATURAL DRAINAGE CHANNEL PEAK FLOW AND CAPACITY CALCULATIONS FOR **FUTURE** CONDITIONS

Constant n-value 0.05

| | | Future Hydrologic Conditions | | | | Wash Characteristics | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Drainage Sub-basin | Natural Drainage Wash Responsible for the Drainage of the specified Sub-basin | 10 Year Peak Flows (cfs) | 100 Year Peak Flows (cfs) | Design Flow for Wash at 10 Year Combined Peak Flows (cfs) | Design Flow for Wash at 100 Year Combined Peak Flows (cfs) | Upper Channel Elevation (ft) | Lower Channel Elevation (ft) | Channel Length (ft) | Slope (ft/ft) | Percent Slope (%) | Bottom Width (ft) | Side Slope (run/1) (ft) | Depth (ft) | n-value | Capacity of Channel Q (cfs) | FUTURE Percent Full Under Peak Flow 100 YEAR |
| 1 | Visitors Center Wash | 35.0 | 362.2 | | | | | | | | | | | | | |
| 2 | Park Entrance Wash | 0.7 | 10.1 | | | | | | | | | | | | | |
| 3 | Park Entrance Wash | 3.6 | 37.1 | | | | | | | | | | | | | |
| 4 | Park Entrance Wash | 8.8 | 76.4 | | | | | | | | | | | | | |
| 5 | Coffee Shop Wash | 0.3 | 7.9 | | | | | | | | | | | | | |
| 6 | Watchman Campground Wash | 3.1 | 43.0 | | | | | | | | | | | | | |
| 7 | Blacks Canyon Wash | 62.3 | 409 | 114 | 585 | 4,660 | 3,873 | 8,286 | 0.095 | 9.5% | 5 | 1 | 5 | 0.05 | 871 | 67% |
| 8 | Blacks Canyon Wash | 4.5 | 53 | | | | | | | | | | | | | |
| 9 | Zion Canyon Campgound Wash | 0.1 | 5 | | | | | | | | | | | | | |
| 10 | Zion Canyon Campgound Wash | 0.0 | 3 | | | | | | | | | | | | | |
| 11 | La Quinta Wash | 0.9 | 17.1 | | | | | | | | | | | | | |
| 12 | Desert Pearl Inn Wash | 13.8 | 130 | 27 | 155 | 4,081 | 3,846 | 1,976 | 0.119 | 11.9% | 3 | 1 | 4 | 0.05 | 450 | 34% |
| 13 | Desert Pearl Inn Wash | 0.0 | 1 | | | | | | | | | | | | | |
| 14 | Canyon Springs Dr Wash | 7.2 | 63 | 14 | 76 | 4,160 | 3,834 | 2,117 | 0.154 | 15.4% | 2 | 1 | 3 | 0.05 | 223 | 34% |
| 15 | Canyon Springs Dr Wash | 0.6 | 14 | | | | | | | | | | | | | |
| 16 | Springdale Wash | 41.8 | 286 | 74 | 350 | 4,150 | 3,841 | 5,666 | 0.055 | 5.5% | 6 | 1 | 8 | 0.05 | 1,935 | 18% |
| 17 | Springdale Wash | 4.6 | 44 | | | | | | | | | | | | | |
| 18 | Springdale Wash | 0.0 | 2 | | | | | | | | | | | | | |
| 19 | Gifford Park Ln Wash | 8.5 | 67 | 19 | 140 | 4,005 | 3,834 | 2,904 | 0.059 | 5.9% | 6 | 1 | 4 | 0.05 | 506 | 28% |
| 20 | Gifford Park Ln Wash | 2.4 | 29 | | | | | | | | | | | | | |
| 21 | Canyon Cove Circle Wash | 15.1 | 134 | 26 | 174 | 3,963 | 3,833 | 2,311 | 0.056 | 5.6% | 8 | 1 | 5 | 0.05 | 942 | 18% |
| 22 | River Bend Circle Wash | 0.4 | 17 | | | | | | | | | | | | | |
| 23 | Claret Cup East Wash | 0.0 | 3.5 | | | | | | | | | | | | | |
| 24 | Claret Cup Wash | 7.8 | 70 | 20 | 95 | 4,163 | 3,825 | 3,099 | 0.109 | 10.9% | 3 | 1 | 4 | 0.05 | 431 | 22% |
| 25 | Claret Cup Wash | 1.2 | 28 | | | | | | | | | | | | | |
| 26 | Serendipity Ln Wash | 33.4 | 210 | 60 | 270 | 3,939 | 3,802 | 2,803 | 0.049 | 4.9% | 6 | 1 | 5 | 0.05 | 708 | 38% |
| 27 | Serendipity Ln Wash | 6.5 | 48 | | | | | | | | | | | | | |
| 28 | Serendipity Ln Wash | 0.6 | 16 | | | | | | | | | | | | | |
| 29 | Serendipity Ln Wash West | 2.2 | 26 | | | | | | | | | | | | | |
| 30 | Dixie Ln Wash | 0.0 | 6 | | | | | | | | | | | | | |
| 31 | Valley View Dr Wash | 0.0 | 5 | 0 | 5 | 3,932 | 3,825 | 1,557 | 0.069 | 6.9% | 2 | 1 | 3 | 0.05 | 149 | 3% |
| 32 | North Fork Dr Wash | 1.3 | 54 | 1 | 62 | 3,904 | 3,806 | 2,329 | 0.042 | 4.2% | | 1 | | | | |
| 33 | River Confluence Wash | 0.0 | 1 | | | | | | | | | | | | | |
| 34 | East Anasazi Wash | 22.5 | 145 | 34 | 165 | 4,108 | 3,890 | 4,366 | 0.050 | 5.0% | 20 | 1 | 6 | 0.05 | 2,713 | 6% |
| 35 | West Anasazi Wash | 19.1 | 128 | 110 | 490 | 4,071 | 3,926 | 5,662 | 0.026 | 2.6% | 20 | 1 | 9 | 0.05 | 3,991 | 12% |
| 36 | West Anasazi Wash | 54.8 | 319 | | | | | | | | | | | | | |
| 37 | East and West Anasazi Wash | 1.3 | 60 | 143 | 715 | 4,071 | 3,926 | 5,662 | 0.026 | 2.6% | 20 | 1 | 9 | 0.05 | 3,991 | 18% |

**NOAA Atlas 14, Volume 1, Version 5**
**Location name: Springdale, Utah, USA***
**Latitude: 37.1896°, Longitude: -112.9958°**
**Elevation: 3883.1 ft****
* source: ESRI Maps
** source: USGS

## 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 | **0.142** (0.121-0.168) | **0.182** (0.156-0.217) | **0.251** (0.214-0.298) | **0.313** (0.263-0.370) | **0.408** (0.337-0.485) | **0.492** (0.401-0.584) | **0.591** (0.469-0.706) | **0.705** (0.544-0.850) | **0.884** (0.655-1.08) | **1.05** (0.747-1.30) |
| 10-min | **0.215** (0.184-0.255) | **0.277** (0.238-0.330) | **0.382** (0.326-0.454) | **0.476** (0.400-0.564) | **0.621** (0.514-0.737) | **0.750** (0.610-0.889) | **0.900** (0.714-1.08) | **1.07** (0.828-1.29) | **1.35** (0.997-1.65) | **1.59** (1.14-1.97) |
| 15-min | **0.267** (0.228-0.316) | **0.343** (0.294-0.409) | **0.474** (0.404-0.562) | **0.590** (0.496-0.699) | **0.770** (0.637-0.914) | **0.930** (0.756-1.10) | **1.12** (0.886-1.33) | **1.33** (1.03-1.60) | **1.67** (1.24-2.04) | **1.97** (1.41-2.44) |
| 30-min | **0.360** (0.307-0.425) | **0.462** (0.397-0.551) | **0.638** (0.543-0.758) | **0.794** (0.668-0.941) | **1.04** (0.858-1.23) | **1.25** (1.02-1.49) | **1.50** (1.19-1.79) | **1.79** (1.38-2.16) | **2.25** (1.66-2.75) | **2.65** (1.90-3.29) |
| 60-min | **0.445** (0.380-0.526) | **0.572** (0.491-0.681) | **0.790** (0.673-0.937) | **0.983** (0.827-1.17) | **1.28** (1.06-1.52) | **1.55** (1.26-1.84) | **1.86** (1.48-2.22) | **2.22** (1.71-2.67) | **2.78** (2.06-3.40) | **3.28** (2.35-4.07) |
| 2-hr | **0.537** (0.466-0.620) | **0.678** (0.588-0.785) | **0.902** (0.781-1.04) | **1.11** (0.947-1.28) | **1.42** (1.19-1.63) | **1.69** (1.40-1.96) | **2.01** (1.63-2.35) | **2.38** (1.88-2.81) | **2.97** (2.24-3.55) | **3.49** (2.55-4.24) |
| 3-hr | **0.600** (0.532-0.686) | **0.756** (0.669-0.867) | **0.983** (0.869-1.13) | **1.18** (1.04-1.35) | **1.48** (1.28-1.69) | **1.74** (1.48-2.00) | **2.05** (1.71-2.37) | **2.41** (1.97-2.82) | **2.98** (2.35-3.59) | **3.50** (2.69-4.28) |
| 6-hr | **0.754** (0.675-0.850) | **0.943** (0.846-1.07) | **1.20** (1.07-1.35) | **1.41** (1.25-1.60) | **1.72** (1.51-1.95) | **1.98** (1.71-2.25) | **2.26** (1.94-2.59) | **2.62** (2.20-3.03) | **3.20** (2.62-3.76) | **3.72** (2.97-4.43) |
| 12-hr | **0.966** (0.868-1.08) | **1.21** (1.08-1.35) | **1.51** (1.35-1.69) | **1.76** (1.57-1.97) | **2.10** (1.86-2.35) | **2.37** (2.08-2.67) | **2.65** (2.30-3.00) | **2.96** (2.54-3.37) | **3.44** (2.89-3.97) | **3.94** (3.26-4.60) |
| 24-hr | **1.24** (1.15-1.34) | **1.55** (1.44-1.66) | **1.93** (1.80-2.08) | **2.24** (2.09-2.42) | **2.68** (2.47-2.89) | **3.01** (2.77-3.26) | **3.37** (3.08-3.66) | **3.74** (3.38-4.08) | **4.24** (3.79-4.67) | **4.64** (4.09-5.14) |
| 2-day | **1.41** (1.32-1.52) | **1.76** (1.65-1.89) | **2.20** (2.06-2.35) | **2.56** (2.40-2.73) | **3.05** (2.85-3.27) | **3.44** (3.19-3.69) | **3.84** (3.53-4.14) | **4.26** (3.89-4.62) | **4.82** (4.34-5.28) | **5.27** (4.69-5.81) |
| 3-day | **1.53** (1.43-1.64) | **1.91** (1.79-2.05) | **2.38** (2.23-2.55) | **2.78** (2.60-2.96) | **3.31** (3.09-3.54) | **3.74** (3.46-4.01) | **4.18** (3.84-4.50) | **4.64** (4.23-5.03) | **5.27** (4.73-5.76) | **5.77** (5.11-6.35) |
| 4-day | **1.65** (1.54-1.76) | **2.06** (1.93-2.20) | **2.57** (2.40-2.74) | **2.99** (2.80-3.19) | **3.58** (3.32-3.81) | **4.04** (3.73-4.32) | **4.52** (4.16-4.87) | **5.02** (4.58-5.44) | **5.71** (5.12-6.25) | **6.26** (5.54-6.90) |
| 7-day | **1.91** (1.78-2.07) | **2.40** (2.24-2.59) | **3.01** (2.80-3.24) | **3.50** (3.25-3.77) | **4.18** (3.86-4.50) | **4.70** (4.33-5.09) | **5.25** (4.81-5.70) | **5.82** (5.27-6.34) | **6.58** (5.90-7.25) | **7.18** (6.35-7.96) |
| 10-day | **2.11** (1.96-2.28) | **2.66** (2.47-2.87) | **3.38** (3.13-3.63) | **3.95** (3.65-4.25) | **4.75** (4.37-5.12) | **5.38** (4.92-5.82) | **6.04** (5.47-6.57) | **6.72** (6.02-7.36) | **7.66** (6.77-8.47) | **8.40** (7.34-9.37) |
| 20-day | **2.71** (2.54-2.91) | **3.39** (3.17-3.64) | **4.21** (3.93-4.51) | **4.87** (4.54-5.21) | **5.74** (5.33-6.13) | **6.41** (5.93-6.86) | **7.09** (6.52-7.61) | **7.77** (7.09-8.39) | **8.67** (7.82-9.45) | **9.36** (8.35-10.3) |
| 30-day | **3.32** (3.09-3.57) | **4.14** (3.86-4.45) | **5.13** (4.78-5.51) | **5.90** (5.48-6.33) | **6.90** (6.38-7.40) | **7.65** (7.04-8.22) | **8.40** (7.69-9.06) | **9.13** (8.29-9.89) | **10.1** (9.06-11.0) | **10.8** (9.62-11.8) |
| 45-day | **3.96** (3.68-4.28) | **4.97** (4.61-5.36) | **6.24** (5.77-6.72) | **7.22** (6.67-7.78) | **8.53** (7.85-9.22) | **9.53** (8.72-10.3) | **10.5** (9.59-11.5) | **11.6** (10.4-12.7) | **12.9** (11.5-14.2) | **13.9** (12.3-15.5) |
| 60-day | **4.65** (4.30-5.05) | **5.84** (5.39-6.34) | **7.34** (6.76-7.97) | **8.52** (7.84-9.23) | **10.1** (9.25-11.0) | **11.3** (10.3-12.3) | **12.6** (11.4-13.7) | **13.8** (12.4-15.2) | **15.5** (13.7-17.2) | **16.8** (14.7-18.7) |

[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.

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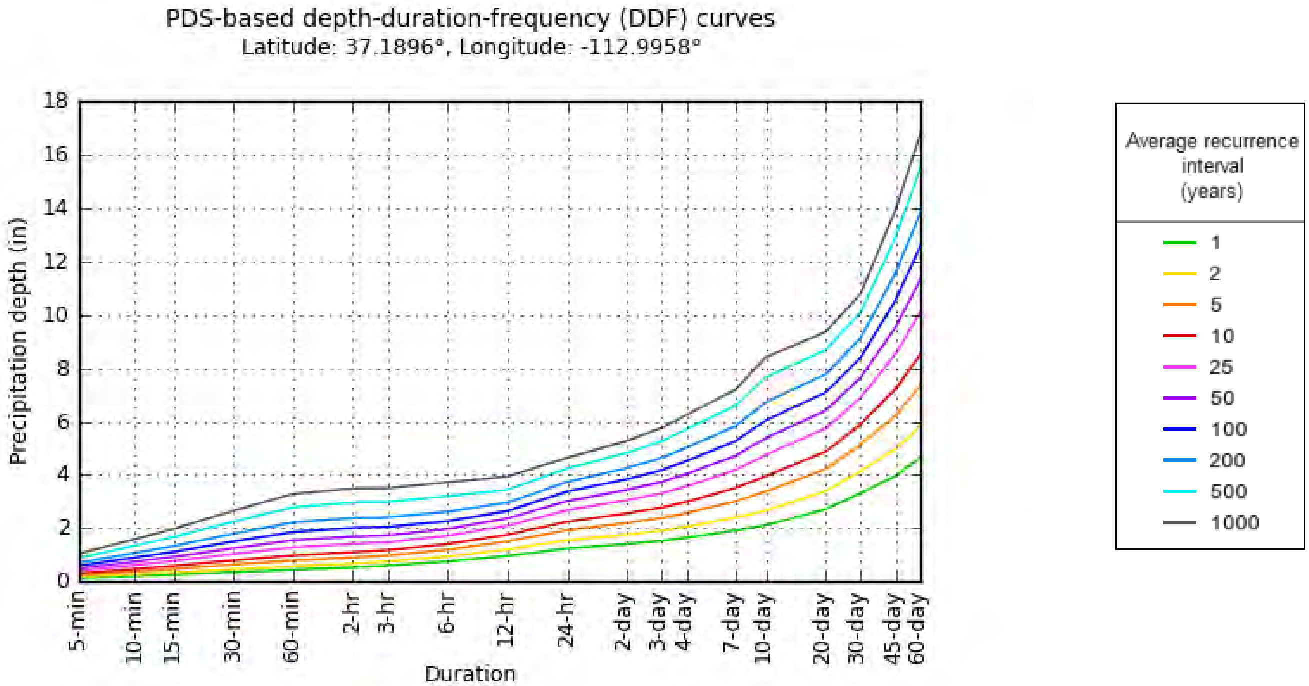
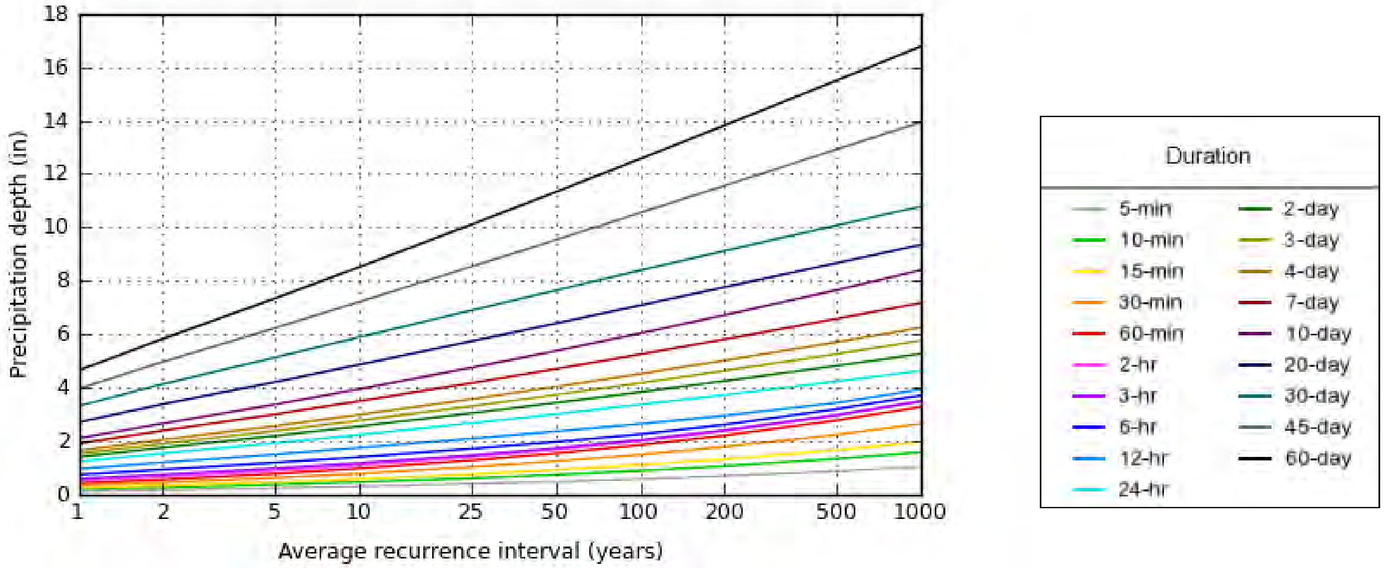
# PF graphical




NOAA Atlas 14, Volume 1, Version 5 Created (GMT): Tue May 19 18:58:41 2020

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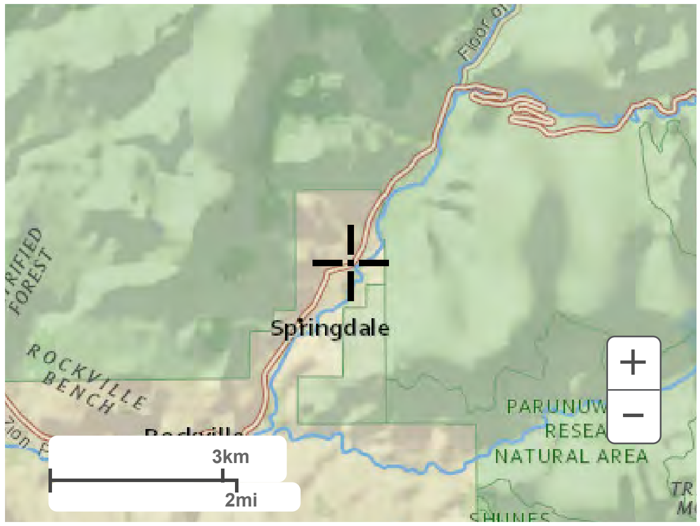
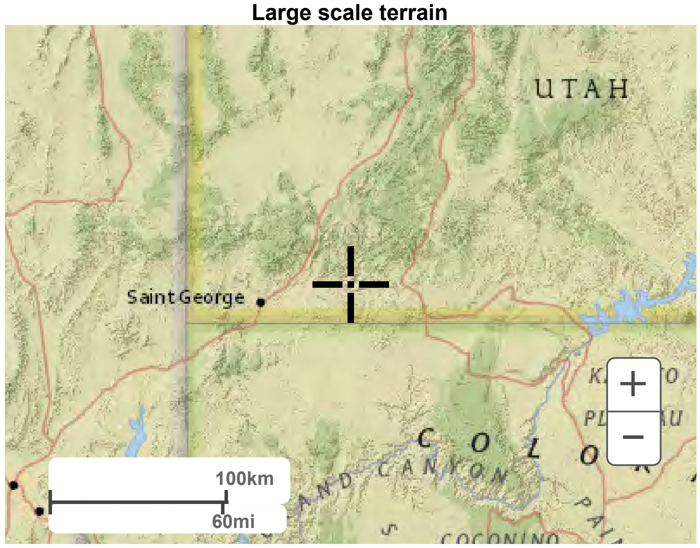
## Maps & aerials

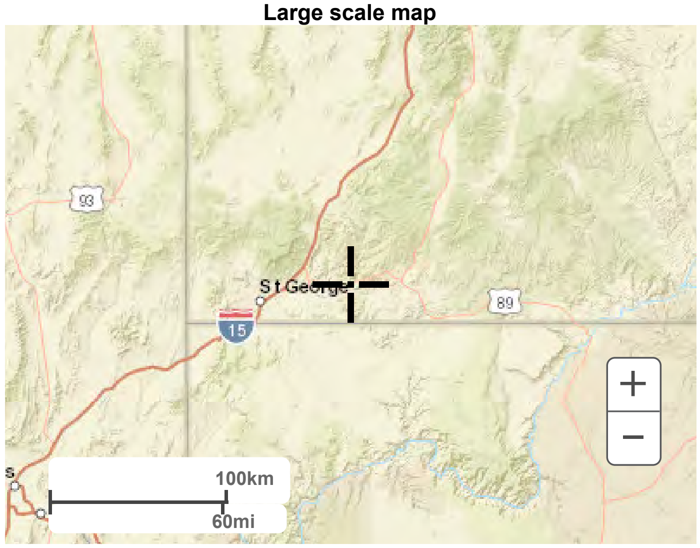
**Small scale terrain**



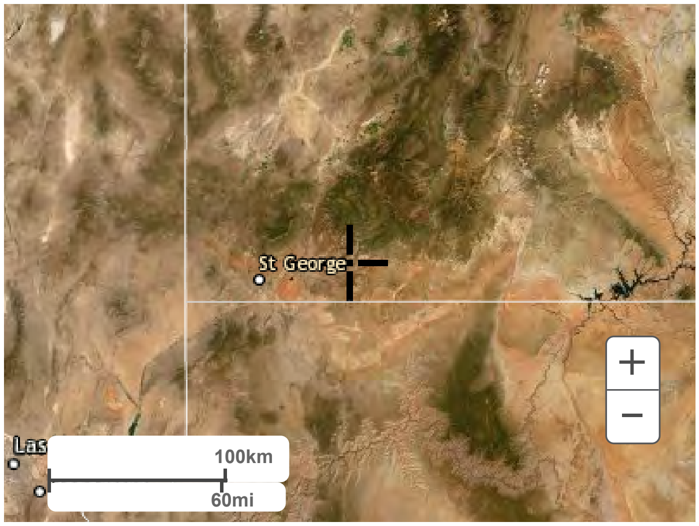

**Large scale terrain**




**Large scale map**




**Large scale aerial**

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US Department of Commerce
National Oceanic and Atmospheric Administration
National Weather Service
National Water Center
1325 East West Highway
Silver Spring, MD 20910
Questions?: HDSC.Questions@noaa.gov

Disclaimer

# Peak Flow Calculations for Pipeline from Cross Gutter and Grate to Daylight

| Valley View Drive | | | | |
|---|---|---|---|---|
| Width | (ft) | 25 | | |
| Length | (ft) | 1200 | | |
| Area | (acres) | 0.69 | | |
| Change in Elevation | (ft) | 112 | | |
| | | | | |
| Return Period | (years) | 10 | | |
| Runoff Coefficient (asphalt) | | 0.72 | | |
| Rainfall Intensity | (in./hr) | 2.36 | | |
| | | | | |
| Return Period | (years) | 100 | | |
| Runoff Coefficient (asphalt) | | 0.82 | | |
| Rainfall Intensity | (in./hr) | 4.46 | | |
| | | | | |
| Velocity (gutter flow) | (ft/sec) | 12.95 | | |
| Time of Concentration | (hr) | 0.03 | (min) | 15 |
| Percent Slope | (%) | 9.3% | | |
| Soil Type | | B | | |
| | | | | |
| Peak Discharge (10 Year) | (cfs) | 1.2 | | |
| Peak Discharge (100 Year) | (cfs) | 2.5 | | |
| | | | | |
| Required Pipe Size | (inches) | 10.5 | (mannings formula) | |
| Nearest Pipe Size | (inches) | 12 | | |
| | | | | |
| Pipe Slope | (ft/ft) | 0.01 | | |
| n (Reinforced Concrete) | | 0.013 | | |

| 10-Year Freq. | |
|---|---|
| Min | Rainfall Intensity |
| 5 | 3.76 |
| 10 | 2.86 |
| 15 | 2.36 |
| 30 | 1.59 |
| 60 | 0.983 |
| 120 | 0.553 |

| 100-year Freq. | |
|---|---|
| Min | Rainfall Intensity |
| 5 | 7.09 |
| 10 | 5.4 |
| 15 | 4.46 |
| 30 | 3 |
| 60 | 1.86 |
| 120 | 1.01 |

# Peak Flow Calculations for Pipeline from Cross Gutter and Grate to Daylight

| Kinesava Drive | | | | |
|---|---|---|---|---|
| Width | (ft) | 25 | | |
| Length | (ft) | 1100 | | |
| Area | (acres) | 0.63 | | |
| Change in Elevation | (ft) | 65 | | |
| | | | | |
| Return Period | (years) | 10 | | |
| Runoff Coefficient (asphalt) | | 0.72 | | |
| Rainfall Intensity | (in./hr) | 2.36 | | |
| | | | | |
| Return Period | (years) | 100 | | |
| Runoff Coefficient (asphalt) | | 0.82 | | |
| Rainfall Intensity | (in./hr) | 4.46 | | |
| | | | | |
| Velocity (gutter flow) | (ft/sec) | 10.31 | | |
| Time of Concentration | (hr) | 0.03 | (min) | 15 |
| Percent Slope | (%) | 5.9% | | |
| Soil Type | | B | | |
| | | | | |
| Peak Discharge (10 Year) | (cfs) | 1.1 | | |
| Peak Discharge (100 Year) | (cfs) | 2.3 | | |
| | | | | |
| Required Pipe Size | (inches) | 10.2 | (mannings formula) | |
| Nearest Pipe Size | (inches) | 12 | | |
| | | | | |
| Pipe Slope | (ft/ft) | 0.01 | | |
| n (Reinforced Concrete) | | 0.013 | | |

| 10-Year Freq. | |
|---|---|
| Min | Rainfall Intensity |
| 5 | 3.76 |
| 10 | 2.86 |
| 15 | 2.36 |
| 30 | 1.59 |
| 60 | 0.983 |
| 120 | 0.553 |

| 100-year Freq. | |
|---|---|
| Min | Rainfall Intensity |
| 5 | 7.09 |
| 10 | 5.4 |
| 15 | 4.46 |
| 30 | 3 |
| 60 | 1.86 |
| 120 | 1.01 |

# Peak Flow Calculations for Pipeline from Cross Gutter and Grate to Daylight

| Dixie Lane | | | | |
|---|---|---|---|---|
| Width | (ft) | 25 | | |
| Length | (ft) | 800 | | |
| Area | (acres) | 0.46 | | |
| Change in Elevation | (ft) | 65 | | |
| Return Period | (years) | 10 | | |
| Runoff Coefficient (asphalt) | | 0.72 | | |
| Rainfall Intensity | (in./hr) | 2.36 | | |
| Return Period | (years) | 100 | | |
| Runoff Coefficient (asphalt) | | 0.82 | | |
| Rainfall Intensity | (in./hr) | 4.46 | | |
| Velocity (gutter flow) | (ft/sec) | 12.09 | | |
| Time of Concentration | (hr) | 0.02 | (min) | 15 |
| Percent Slope | (%) | 8.1% | | |
| Soil Type | | B | | |
| Peak Discharge (10 Year) | (cfs) | 0.8 | | |
| Peak Discharge (100 Year) | (cfs) | 1.7 | | |
| Required Pipe Size | (inches) | 9.0 | (mannings formula) | |
| Nearest Pipe Size | (inches) | 10 | | |
| Pipe Slope | (ft/ft) | 0.01 | | |
| n (Reinforced Concrete) | | 0.013 | | |

| 10-Year Freq. | |
|---|---|
| Min | Rainfall Intensity |
| 5 | 3.76 |
| 10 | 2.86 |
| 15 | 2.36 |
| 30 | 1.59 |
| 60 | 0.983 |
| 120 | 0.553 |

| 100-year Freq. | |
|---|---|
| Min | Rainfall Intensity |
| 5 | 7.09 |
| 10 | 5.4 |
| 15 | 4.46 |
| 30 | 3 |
| 60 | 1.86 |
| 120 | 1.01 |

# Peak Flow Calculations for Pipeline from Cross Gutter and Grate to Daylight

## West Temple Drive

| | | | | |
|---|---|---|---|---|
| Width | (ft) | 25 | | |
| Length | (ft) | 450 | | |
| Area | (acres) | 0.26 | | |
| Change in Elevation | (ft) | 15 | | |
| | | | | |
| Return Period | (years) | 10 | | |
| Runoff Coefficient (asphalt) | | 0.72 | | |
| Rainfall Intensity | (in./hr) | 3.76 | | |
| | | | | |
| Return Period | (years) | 100 | | |
| Runoff Coefficient (asphalt) | | 0.82 | | |
| Rainfall Intensity | (in./hr) | 7.09 | | |
| | | | | |
| Velocity (gutter flow) | (ft/sec) | 7.74 | | |
| Time of Concentration | (hr) | 0.02 | (min) | 5 |
| Percent Slope | (%) | 3.3% | | |
| Soil Type | | B | | |
| | | | | |
| Peak Discharge (10 Year) | (cfs) | 0.7 | | |
| Peak Discharge (100 Year) | (cfs) | 1.5 | | |
| | | | | |
| Required Pipe Size | (inches) | 8.7 | (mannings formula) | |
| Nearest Pipe Size | (inches) | 10 | | |
| | | | | |
| Pipe Slope | (ft/ft) | 0.01 | | |
| n (Reinforced Concrete) | | 0.013 | | |

| 10-Year Freq. | |
|---|---|
| Min | Rainfall Intensity |
| 5 | 3.76 |
| 10 | 2.86 |
| 15 | 2.36 |
| 30 | 1.59 |
| 60 | 0.983 |
| 120 | 0.553 |

| 100-year Freq. | |
|---|---|
| Min | Rainfall Intensity |
| 5 | 7.09 |
| 10 | 5.4 |
| 15 | 4.46 |
| 30 | 3 |
| 60 | 1.86 |
| 120 | 1.01 |

# Peak Flow Calculations for Pipeline from Cross Gutter and Grate to Daylight

| Balanced Rock Road | | | | |
|---|---|---|---|---|
| Width | (ft) | 25 | | |
| Length | (ft) | 600 | | |
| Area | (acres) | 0.34 | | |
| Change in Elevation | (ft) | 67 | | |
| | | | | |
| Return Period | (years) | 10 | | |
| Runoff Coefficient (asphalt) | | 0.72 | | |
| Rainfall Intensity | (in./hr) | 3.76 | | |
| | | | | |
| Return Period | (years) | 100 | | |
| Runoff Coefficient (asphalt) | | 0.82 | | |
| Rainfall Intensity | (in./hr) | 7.09 | | |
| | | | | |
| Velocity (gutter flow) | (ft/sec) | 14.17 | | |
| Time of Concentration | (hr) | 0.01 | (min) | 5 |
| Percent Slope | (%) | 11.2% | | |
| Soil Type | | B | | |
| | | | | |
| Peak Discharge (10 Year) | (cfs) | 0.9 | | |
| Peak Discharge (100 Year) | (cfs) | 2.0 | | |
| | | | | |
| Required Pipe Size | (inches) | 9.6 | (mannings formula) | |
| Nearest Pipe Size | (inches) | 10 | | |
| | | | | |
| Pipe Slope | (ft/ft) | 0.01 | | |
| n (Reinforced Concrete) | | 0.013 | | |

| 10-Year Freq. | |
|---|---|
| Min | Rainfall Intensity |
| 5 | 3.76 |
| 10 | 2.86 |
| 15 | 2.36 |
| 30 | 1.59 |
| 60 | 0.983 |
| 120 | 0.553 |

| 100-year Freq. | |
|---|---|
| Min | Rainfall Intensity |
| 5 | 7.09 |
| 10 | 5.4 |
| 15 | 4.46 |
| 30 | 3 |
| 60 | 1.86 |
| 120 | 1.01 |

# ROADWAY CAPACITY AND PEAK FLOW CALCULATIONS

## Valley View Drive

SWALES ON EACH SIDE OF THE ROADWAY

| | | | | |
|---|---|---|---|---|
| Width | (ft) | 20 | | |
| Length | (ft) | 975 | | |
| Area | (acres) | 0.45 | | |
| Change in Elevation | (ft) | 110 | | |
| Return Period | (years) | 10 | | |
| Runoff Coefficient (asphalt) | | 0.72 | | |
| Rainfall Intensity | (in./hr) | 2.36 | | |
| Return Period | (years) | 100 | | |
| Runoff Coefficient (asphalt) | | 0.82 | | |
| Rainfall Intensity | (in./hr) | 4.46 | | |
| Velocity (gutter flow) | (ft/sec) | 6.72 | | |
| Time of Concentration | (hr) | 0.04 | (min) | 15 |
| Percent Slope | (%) | 11.3% | | |
| Soil Type | | B | | |
| Peak Discharge (10 Year) | (cfs) | 0.76464 | | |
| Peak Discharge (100 Year) | (cfs) | 1.64574 | | |
| Capacity of Swales on Both Sides | (cfs) | 6.784931 | | |

| 10 Year Return Period | |
|---|---|
| Min | Rainfall Intensity |
| 5 | 3.76 |
| 10 | 2.86 |
| 15 | 2.36 |
| 30 | 1.59 |
| 60 | 0.983 |
| 120 | 0.553 |

| 100 Year Return Period | |
|---|---|
| Min | Rainfall Intensity |
| 5 | 7.09 |
| 10 | 5.4 |
| 15 | 4.46 |
| 30 | 3 |
| 60 | 1.86 |
| 120 | 1.01 |

## Serendipity Lane

SWALES ON EACH SIDE OF THE ROADWAY

| | | | | |
|---|---|---|---|---|
| Width | (ft) | 20 | | |
| Length | (ft) | 775 | | |
| Area | (acres) | 0.36 | | |
| Change in Elevation | (ft) | 52 | | |
| Return Period | (years) | 10 | | |
| Runoff Coefficient (asphalt) | | 0.72 | | |
| Rainfall Intensity | (in./hr) | 2.36 | | |
| Return Period | (years) | 100 | | |
| Runoff Coefficient (asphalt) | | 0.82 | | |
| Rainfall Intensity | (in./hr) | 4.46 | | |
| Velocity (gutter flow) | (ft/sec) | 5.18 | | |
| Time of Concentration | (hr) | 0.04 | (min) | 15 |
| Percent Slope | (%) | 6.7% | | |
| Soil Type | | B | | |
| Peak Discharge (10 Year) | (cfs) | 0.611712 | | |
| Peak Discharge (100 Year) | (cfs) | 1.316592 | | |
| Capacity of Swales on Both Sides | (cfs) | 5.232415 | | |

| 10 Year Return Period | |
|---|---|
| Min | Rainfall Intensity |
| 5 | 3.76 |
| 10 | 2.86 |
| 15 | 2.36 |
| 30 | 1.59 |
| 60 | 0.983 |
| 120 | 0.553 |

| 100 Year Return Period | |
|---|---|
| Min | Rainfall Intensity |
| 5 | 7.09 |
| 10 | 5.4 |
| 15 | 4.46 |
| 30 | 3 |
| 60 | 1.86 |
| 120 | 1.01 |

# ROADWAY CAPACITY AND PEAK FLOW CALCULATIONS

## Gifford Park Lane

SWALES ON EACH SIDE OF THE ROADWAY

| | | | | |
|---|---|---|---|---|
| Width | (ft) | 25 | | |
| Length | (ft) | 870 | | |
| Area | (acres) | 0.5 | | |
| Change in Elevation | (ft) | 72 | | |
| Return Period | (years) | 10 | | |
| Runoff Coefficient (asphalt) | | 0.72 | | |
| Rainfall Intensity | (in./hr) | 2.36 | | |
| Return Period | (years) | 100 | | |
| Runoff Coefficient (asphalt) | | 0.82 | | |
| Rainfall Intensity | (in./hr) | 4.46 | | |
| Velocity (gutter flow) | (ft/sec) | 5.75 | | |
| Time of Concentration | (hr) | 0.04 | (min) | 15 |
| Percent Slope | (%) | 8.3% | | |
| Soil Type | | B | | |
| Peak Discharge (10 Year) | (cfs) | 0.8496 | | |
| Peak Discharge (100 Year) | (cfs) | 1.8286 | | |
| Capacity of Swales on Both Sides | (cfs) | 5.811095 | | |

| 10 Year Return Period | |
|---|---|
| Min | Rainfall Intensity |
| 5 | 3.76 |
| 10 | 2.86 |
| 15 | 2.36 |
| 30 | 1.59 |
| 60 | 0.983 |
| 120 | 0.553 |

| 100 Year Return Period | |
|---|---|
| Min | Rainfall Intensity |
| 5 | 7.09 |
| 10 | 5.4 |
| 15 | 4.46 |
| 30 | 3 |
| 60 | 1.86 |
| 120 | 1.01 |

## Winderland Lane

CURB/GUTTER

| | | | | |
|---|---|---|---|---|
| Width | (ft) | 25 | | |
| Length | (ft) | 1065 | | |
| Area | (acres) | 0.61 | | |
| Change in Elevation | (ft) | 26 | | |
| Return Period | (years) | 10 | | |
| Runoff Coefficient (asphalt) | | 0.72 | | |
| Rainfall Intensity | (in./hr) | 2.36 | | |
| Return Period | (years) | 100 | | |
| Runoff Coefficient (asphalt) | | 0.82 | | |
| Rainfall Intensity | (in./hr) | 4.46 | | |
| Velocity (gutter flow) | (ft/sec) | 3.12 | | |
| Time of Concentration | (hr) | 0.09 | (min) | 15 |
| Percent Slope | (%) | 2.4% | | |
| Soil Type | | B | | |
| Peak Discharge (10 Year) | (cfs) | 1.036512 | | |
| Peak Discharge (100 Year) | (cfs) | 2.230892 | | |
| Capacity of Swales on Both Sides | (cfs) | 39.34301 | | |

| 10 Year Return Period | |
|---|---|
| Min | Rainfall Intensity |
| 5 | 3.76 |
| 10 | 2.86 |
| 15 | 2.36 |
| 30 | 1.59 |
| 60 | 0.983 |
| 120 | 0.553 |

| 100 Year Return Period | |
|---|---|
| Min | Rainfall Intensity |
| 5 | 7.09 |
| 10 | 5.4 |
| 15 | 4.46 |
| 30 | 3 |
| 60 | 1.86 |
| 120 | 1.01 |

# ROADWAY CAPACITY AND PEAK FLOW CALCULATIONS

## Paradise Road

CURB/GUTTER

| | | | | |
|---|---|---|---|---|
| Width | (ft) | 20 | | |
| Length | (ft) | 1900 | | |
| Area | (acres) | 0.87 | | |
| Change in Elevation | (ft) | 75 | | |
| Return Period | (years) | 10 | | |
| Runoff Coefficient (asphalt) | | 0.72 | | |
| Rainfall Intensity | (in./hr) | 2.36 | | |
| Return Period | (years) | 100 | | |
| Runoff Coefficient (asphalt) | | 0.82 | | |
| Rainfall Intensity | (in./hr) | 4.46 | | |
| Velocity (gutter flow) | (ft/sec) | 8.42 | | |
| Time of Concentration | (hr) | 0.06 | (min) | 15 |
| Percent Slope | (%) | 3.9% | | |
| Soil Type | | B | | |
| Peak Discharge (10 Year) | (cfs) | 1.478304 | | |
| Peak Discharge (100 Year) | (cfs) | 3.181764 | | |
| Capacity of Swales on Both Sides | (cfs) | 50.02759 | | |

| 10 Year Return Period | |
|---|---|
| Min | Rainfall Intensity |
| 5 | 3.76 |
| 10 | 2.86 |
| 15 | 2.36 |
| 30 | 1.59 |
| 60 | 0.983 |
| 120 | 0.553 |

| 100 Year Return Period | |
|---|---|
| Min | Rainfall Intensity |
| 5 | 7.09 |
| 10 | 5.4 |
| 15 | 4.46 |
| 30 | 3 |
| 60 | 1.86 |
| 120 | 1.01 |

## Zion Shadows Circle

INVERTED CROWN ROADWAY

| | | | | |
|---|---|---|---|---|
| Width | (ft) | 25 | | |
| Length | (ft) | 861 | | |
| Area | (acres) | 0.49 | | |
| Change in Elevation | (ft) | 52 | | |
| Return Period | (years) | 10 | | |
| Runoff Coefficient (asphalt) | | 0.72 | | |
| Rainfall Intensity | (in./hr) | 2.36 | | |
| Return Period | (years) | 100 | | |
| Runoff Coefficient (asphalt) | | 0.82 | | |
| Rainfall Intensity | (in./hr) | 4.46 | | |
| Velocity (gutter flow) | (ft/sec) | 2.76 | | |
| Time of Concentration | (hr) | 0.09 | (min) | 15 |
| Percent Slope | (%) | 1.9% | | |
| Soil Type | | B | | |
| Peak Discharge (10 Year) | (cfs) | 0.832608 | | |
| Peak Discharge (100 Year) | (cfs) | 1.792028 | | |
| Capacity of Roadway | (cfs) | 34.70823 | | |

| 10 Year Return Period | |
|---|---|
| Min | Rainfall Intensity |
| 5 | 3.76 |
| 10 | 2.86 |
| 15 | 2.36 |
| 30 | 1.59 |
| 60 | 0.983 |
| 120 | 0.553 |

| 100 Year Return Period | |
|---|---|
| Min | Rainfall Intensity |
| 5 | 7.09 |
| 10 | 5.4 |
| 15 | 4.46 |
| 30 | 3 |
| 60 | 1.86 |
| 120 | 1.01 |

# ROADWAY CAPACITY AND PEAK FLOW CALCULATIONS

## Lion Blvd

CURB/GUTTER

| | | | | |
|---|---|---|---|---|
| Width | (ft) | 25 | | |
| Length | (ft) | 4043 | | |
| Area | (acres) | 2.32 | | |
| Change in Elevation | (ft) | 96 | | |
| | | | | |
| Return Period | (years) | 10 | | |
| Runoff Coefficient (asphalt) | | 0.72 | | |
| Rainfall Intensity | (in./hr) | 2.36 | | |
| | | | | |
| Return Period | (years) | 100 | | |
| Runoff Coefficient (asphalt) | | 0.82 | | |
| Rainfall Intensity | (in./hr) | 4.46 | | |
| | | | | |
| Velocity (gutter flow) | (ft/sec) | 8.69 | | |
| Time of Concentration | (hr) | 0.13 | (min) | 15 |
| Percent Slope | (%) | 4.2% | | |
| Soil Type | | B | | |
| | | | | |
| Peak Discharge (10 Year) | (cfs) | 3.942144 | | |
| Peak Discharge (100 Year) | (cfs) | 8.484704 | | |
| | | | | |
| Capacity of Swales on Both Sides | (cfs) | 27.87171 | | |

10 Year Return Period

| Min | Rainfall Intensity |
|---|---|
| 5 | 3.76 |
| 10 | 2.86 |
| 15 | 2.36 |
| 30 | 1.59 |
| 60 | 0.983 |
| 120 | 0.553 |

100 Year Return Period

| Min | Rainfall Intensity |
|---|---|
| 5 | 7.09 |
| 10 | 5.4 |
| 15 | 4.46 |
| 30 | 3 |
| 60 | 1.86 |
| 120 | 1.01 |

# APPENDIX D – HYDROLOGIC MODEL OUTPUT

## 10-Year 3-Hour Storm (Existing)

Global Summary Results for Run "10 Year 3 Hour Storm"

Project: Improvements    Simulation Run: 10 Year 3 Hour Storm

Start of Run: 01Jan2000, 00:00    Basin Model: Basin 1
End of Run: 01Jan2000, 23:15    Meteorologic Model: Met 1
Compute Time: 04Apr2020, 17:42:17    Control Specifications: Control 1

Show Elements: All Elements    Volume Units: IN  AC-FT    Sorting: Hydrologic

| Hydrologic Element | Drainage Area (MI2) | Peak Discharge (CFS) | Time of Peak | Volume (IN) |
|---|---|---|---|---|
| Junction-1 | 1.45160 | 197.0 | 01Jan2000, 02:15 | 0.25 |
| Reach-1 | 1.45160 | 197.7 | 01Jan2000, 02:15 | 0.25 |
| 2 | 0.73810 | 128.5 | 01Jan2000, 02:15 | 0.28 |
| 3 | 1.13470 | 142.4 | 01Jan2000, 02:15 | 0.25 |
| 1 | 0.71350 | 74.8 | 01Jan2000, 02:30 | 0.22 |
| 9 | 0.02660 | 9.8 | 01Jan2000, 01:45 | 0.39 |
| Junction-2 | 2.61290 | 343.9 | 01Jan2000, 02:15 | 0.25 |
| Reach-2 | 2.61290 | 324.0 | 01Jan2000, 02:15 | 0.26 |
| Junction-3 | 2.61290 | 324.0 | 01Jan2000, 02:15 | 0.26 |
| 13 Outlet | 0.89610 | 164.3 | 01Jan2000, 02:15 | 0.31 |
| Reach-6 | 0.01148 | 2.1 | 01Jan2000, 01:45 | 0.23 |
| 4 | 0.01010 | 2.4 | 01Jan2000, 01:45 | 0.23 |
| Reach-3 | 0.00000 | 2.1 | 01Jan2000, 01:45 | n/a |
| Junction-8 | 0.01010 | 2.4 | 01Jan2000, 01:45 | 0.23 |
| Reach-5 | 0.01010 | 2.3 | 01Jan2000, 01:45 | 0.23 |
| 7 | 0.00138 | 0.3 | 01Jan2000, 01:45 | 0.19 |
| Junction-9 | 0.01148 | 2.5 | 01Jan2000, 01:45 | 0.23 |
| 10 | 0.04840 | 10.9 | 01Jan2000, 02:00 | 0.27 |
| Junction-10 | 0.05988 | 14.9 | 01Jan2000, 02:00 | 0.31 |
| 11 | 0.04710 | 10.3 | 01Jan2000, 02:15 | 0.36 |
| 12 | 0.00980 | 2.1 | 01Jan2000, 02:15 | 0.35 |
| Junction-6 | 0.05690 | 12.4 | 01Jan2000, 02:15 | 0.36 |
| Reach-4 | 0.05690 | 12.1 | 01Jan2000, 02:15 | 0.36 |
| Junction-7 | 0.05690 | 12.1 | 01Jan2000, 02:15 | 0.36 |
| 8 | 0.02340 | 10.0 | 01Jan2000, 01:45 | 0.36 |
| 5 | 0.01480 | 6.8 | 01Jan2000, 01:45 | 0.38 |
| Junction-14 | 0.01480 | 6.8 | 01Jan2000, 01:45 | 0.38 |
| Reach-9 | 0.01480 | 5.2 | 01Jan2000, 01:45 | 0.39 |
| 6 | 0.01440 | 4.3 | 01Jan2000, 01:45 | 0.27 |
| Junction-12 | 0.01440 | 4.3 | 01Jan2000, 01:45 | 0.27 |
| Reach-8 | 0.01440 | 3.2 | 01Jan2000, 01:45 | 0.27 |
| Junction-13 | 0.05260 | 18.4 | 01Jan2000, 01:45 | 0.34 |

## 100-Year 3-Hour Storm (Existing)

Global Summary Results for Run "100 Year 3 Hour Storm"

Project: Improvements   Simulation Run: 100 Year 3 Hour Storm

Start of Run: 01Jan2000, 00:00   Basin Model: Basin 1
End of Run: 01Jan2000, 23:15   Meteorologic Model: Met 2
Compute Time: 04Apr2020, 17:42:21   Control Specifications: Control 1

Show Elements: All Elements   Volume Units: IN / AC-FT   Sorting: Hydrologic

| Hydrologic Element | Drainage Area (MI2) | Peak Discharge (CFS) | Time of Peak | Volume (IN) |
|---|---|---|---|---|
| Junction-1 | 1.45160 | 684.4 | 01Jan2000, 02:15 | 0.79 |
| Reach-1 | 1.45160 | 696.5 | 01Jan2000, 02:15 | 0.79 |
| 2 | 0.73810 | 419.7 | 01Jan2000, 02:15 | 0.85 |
| 3 | 1.13470 | 510.7 | 01Jan2000, 02:15 | 0.79 |
| 1 | 0.71350 | 270.3 | 01Jan2000, 02:30 | 0.74 |
| 9 | 0.02660 | 29.4 | 01Jan2000, 01:45 | 1.03 |
| Junction-2 | 2.61290 | 1216.2 | 01Jan2000, 02:15 | 0.80 |
| Reach-2 | 2.61290 | 1174.4 | 01Jan2000, 02:15 | 0.80 |
| Junction-3 | 2.61290 | 1174.4 | 01Jan2000, 02:15 | 0.80 |
| 13 Outlet | 0.89610 | 521.9 | 01Jan2000, 02:15 | 0.89 |
| Reach-6 | 0.01148 | 9.1 | 01Jan2000, 01:45 | 0.76 |
| 4 | 0.01010 | 9.6 | 01Jan2000, 01:45 | 0.75 |
| Reach-3 | 0.00000 | 8.7 | 01Jan2000, 01:45 | n/a |
| Junction-8 | 0.01010 | 9.6 | 01Jan2000, 01:45 | 0.75 |
| Reach-5 | 0.01010 | 9.2 | 01Jan2000, 01:45 | 0.76 |
| 7 | 0.00138 | 1.2 | 01Jan2000, 01:45 | 0.67 |
| Junction-9 | 0.01148 | 10.4 | 01Jan2000, 01:45 | 0.75 |
| 10 | 0.04840 | 36.1 | 01Jan2000, 02:00 | 0.83 |
| Junction-10 | 0.05988 | 52.9 | 01Jan2000, 01:45 | 0.96 |
| 11 | 0.04710 | 30.3 | 01Jan2000, 02:15 | 0.98 |
| 12 | 0.00980 | 6.2 | 01Jan2000, 02:15 | 0.96 |
| Junction-6 | 0.05690 | 36.5 | 01Jan2000, 02:15 | 0.98 |
| Reach-4 | 0.05690 | 36.2 | 01Jan2000, 02:15 | 0.98 |
| Junction-7 | 0.05690 | 36.2 | 01Jan2000, 02:15 | 0.98 |
| 8 | 0.02340 | 30.7 | 01Jan2000, 01:45 | 0.98 |
| 5 | 0.01480 | 20.1 | 01Jan2000, 01:45 | 1.02 |
| Junction-14 | 0.01480 | 20.1 | 01Jan2000, 01:45 | 1.02 |
| Reach-9 | 0.01480 | 16.8 | 01Jan2000, 01:45 | 1.04 |
| 6 | 0.01440 | 15.7 | 01Jan2000, 01:45 | 0.82 |
| Junction-12 | 0.01440 | 15.7 | 01Jan2000, 01:45 | 0.82 |
| Reach-8 | 0.01440 | 12.9 | 01Jan2000, 01:45 | 0.84 |
| Junction-13 | 0.05260 | 60.4 | 01Jan2000, 01:45 | 0.96 |

## 10-Year 3-Hour Storm (After Improvements)

Global Summary Results for Run "10 Year 3 Hour Storm"

Project: APPLE VALLEY DRAINAGE  Simulation Run: 10 Year 3 Hour Storm

Start of Run: 01Jan2000, 00:00  Basin Model: Basin 1
End of Run: 01Jan2000, 23:15  Meteorologic Model: Met 1
Compute Time: 03Apr2020, 15:57:34  Control Specifications: Control 1

Show Elements: All Elements  Volume Units: IN  AC-FT  Sorting: Hydrologic

| Hydrologic Element | Drainage Area (MI2) | Peak Discharge (CFS) | Time of Peak | Volume (IN) |
|---|---|---|---|---|
| 3 | 1.13470 | 142.4 | 01Jan2000, 02:15 | 0.25 |
| 1a | 0.30400 | 42.2 | 01Jan2000, 02:00 | 0.22 |
| Junction-2 | 0.92800 | 151.4 | 01Jan2000, 02:15 | 0.26 |
| Junction-1 | 0.30400 | 42.2 | 01Jan2000, 02:00 | 0.22 |
| Junction-3 | 0.92800 | 150.6 | 01Jan2000, 02:15 | 0.26 |
| Reach-2a | 0.92800 | 150.6 | 01Jan2000, 02:15 | 0.26 |
| Reach-1 | 0.30400 | 42.1 | 01Jan2000, 02:15 | 0.22 |
| 2a | 0.62400 | 112.8 | 01Jan2000, 02:00 | 0.28 |
| Reach-2b | 0.92800 | 145.5 | 01Jan2000, 02:15 | 0.26 |
| 9 | 0.02660 | 9.8 | 01Jan2000, 01:45 | 0.39 |
| Junction-4 | 2.08930 | 291.7 | 01Jan2000, 02:15 | 0.26 |
| Reach-3 | 2.08930 | 272.7 | 01Jan2000, 02:15 | 0.26 |
| Junction-5 | 2.08930 | 272.7 | 01Jan2000, 02:15 | 0.26 |
| 13 Outlet | 0.89610 | 164.3 | 01Jan2000, 02:15 | 0.31 |
| 1b | 0.41000 | 48.6 | 01Jan2000, 02:15 | 0.22 |
| 2b | 0.11460 | 16.4 | 01Jan2000, 02:15 | 0.28 |
| Reach-6 | 0.01148 | 2.1 | 01Jan2000, 01:45 | 0.23 |
| 4 | 0.01010 | 2.4 | 01Jan2000, 01:45 | 0.23 |
| Junction-8 | 0.01010 | 2.4 | 01Jan2000, 01:45 | 0.23 |
| Reach-5 | 0.01010 | 2.3 | 01Jan2000, 01:45 | 0.23 |
| 7 | 0.00138 | 0.3 | 01Jan2000, 01:45 | 0.19 |
| Junction-9 | 0.01148 | 2.5 | 01Jan2000, 01:45 | 0.23 |
| 10 | 0.04840 | 10.9 | 01Jan2000, 02:00 | 0.27 |
| Junction-10 | 0.05988 | 12.9 | 01Jan2000, 02:00 | 0.27 |
| 11 | 0.04710 | 10.3 | 01Jan2000, 02:15 | 0.36 |
| 12 | 0.00980 | 2.1 | 01Jan2000, 02:15 | 0.35 |
| Junction-6 | 0.05690 | 12.4 | 01Jan2000, 02:15 | 0.36 |
| Reach-4 | 0.05690 | 12.1 | 01Jan2000, 02:15 | 0.36 |
| Junction-7 | 0.05690 | 12.1 | 01Jan2000, 02:15 | 0.36 |
| Reach-9 | 0.01480 | 5.2 | 01Jan2000, 01:45 | 0.39 |
| Reach-8 | 0.01440 | 3.2 | 01Jan2000, 01:45 | 0.27 |
| 5 | 0.01480 | 6.8 | 01Jan2000, 01:45 | 0.38 |
| 6 | 0.01440 | 4.3 | 01Jan2000, 01:45 | 0.27 |
| 8 | 0.02340 | 10.0 | 01Jan2000, 01:45 | 0.36 |
| Junction-14 | 0.01480 | 6.8 | 01Jan2000, 01:45 | 0.38 |
| Junction-12 | 0.01440 | 4.3 | 01Jan2000, 01:45 | 0.27 |
| Junction-13 | 0.05260 | 18.4 | 01Jan2000, 01:45 | 0.34 |

## 100-Year 3-Hour Storm (After Improvements)

Global Summary Results for Run "100 Year 3 Hour Storm"

Project: APPLE VALLEY DRAINAGE Simulation Run: 100 Year 3 Hour Storm

Start of Run: 01Jan2000, 00:00 Basin Model: Basin 1
End of Run: 01Jan2000, 23:15 Meteorologic Model: Met 2
Compute Time: 03Apr2020, 15:57:39 Control Specifications: Control 1

Show Elements: All Elements Volume Units: IN AC-FT Sorting: Hydrologic

| Hydrologic Element | Drainage Area (MI2) | Peak Discharge (CFS) | Time of Peak | Volume (IN) |
|---|---|---|---|---|
| 3 | 1.13470 | 510.7 | 01Jan2000, 02:15 | 0.79 |
| 1a | 0.30400 | 166.9 | 01Jan2000, 02:00 | 0.74 |
| Junction-2 | 0.92800 | 537.5 | 01Jan2000, 02:00 | 0.81 |
| Junction-1 | 0.30400 | 166.9 | 01Jan2000, 02:00 | 0.74 |
| Junction-3 | 0.92800 | 510.1 | 01Jan2000, 02:15 | 0.82 |
| Reach-2a | 0.92800 | 510.1 | 01Jan2000, 02:15 | 0.82 |
| Reach-1 | 0.30400 | 154.8 | 01Jan2000, 02:15 | 0.74 |
| 2a | 0.62400 | 394.5 | 01Jan2000, 02:00 | 0.85 |
| Reach-2b | 0.92800 | 507.6 | 01Jan2000, 02:15 | 0.82 |
| 9 | 0.02660 | 29.4 | 01Jan2000, 01:45 | 1.03 |
| Junction-4 | 2.08930 | 1027.3 | 01Jan2000, 02:15 | 0.81 |
| Reach-3 | 2.08930 | 993.9 | 01Jan2000, 02:15 | 0.81 |
| Junction-5 | 2.08930 | 993.9 | 01Jan2000, 02:15 | 0.81 |
| 13 Outlet | 0.89610 | 521.9 | 01Jan2000, 02:15 | 0.89 |
| 1b | 0.41000 | 184.0 | 01Jan2000, 02:15 | 0.74 |
| 2b | 0.11460 | 55.8 | 01Jan2000, 02:15 | 0.85 |
| Reach-6 | 0.01148 | 9.1 | 01Jan2000, 01:45 | 0.76 |
| 4 | 0.01010 | 9.6 | 01Jan2000, 01:45 | 0.75 |
| Junction-8 | 0.01010 | 9.6 | 01Jan2000, 01:45 | 0.75 |
| Reach-5 | 0.01010 | 9.2 | 01Jan2000, 01:45 | 0.76 |
| 7 | 0.00138 | 1.2 | 01Jan2000, 01:45 | 0.67 |
| Junction-9 | 0.01148 | 10.4 | 01Jan2000, 01:45 | 0.75 |
| 10 | 0.04840 | 36.1 | 01Jan2000, 02:00 | 0.83 |
| Junction-10 | 0.05988 | 44.2 | 01Jan2000, 01:45 | 0.82 |
| 11 | 0.04710 | 30.3 | 01Jan2000, 02:15 | 0.98 |
| 12 | 0.00980 | 6.2 | 01Jan2000, 02:15 | 0.96 |
| Junction-6 | 0.05690 | 36.5 | 01Jan2000, 02:15 | 0.98 |
| Reach-4 | 0.05690 | 36.2 | 01Jan2000, 02:15 | 0.98 |
| Junction-7 | 0.05690 | 36.2 | 01Jan2000, 02:15 | 0.98 |
| Reach-9 | 0.01480 | 16.8 | 01Jan2000, 01:45 | 1.04 |
| Reach-8 | 0.01440 | 12.9 | 01Jan2000, 01:45 | 0.84 |
| 5 | 0.01480 | 20.1 | 01Jan2000, 01:45 | 1.02 |
| 6 | 0.01440 | 15.7 | 01Jan2000, 01:45 | 0.82 |
| 8 | 0.02340 | 30.7 | 01Jan2000, 01:45 | 0.98 |
| Junction-14 | 0.01480 | 20.1 | 01Jan2000, 01:45 | 1.02 |
| Junction-12 | 0.01440 | 15.7 | 01Jan2000, 01:45 | 0.82 |
| Junction-13 | 0.05260 | 60.4 | 01Jan2000, 01:45 | 0.96 |