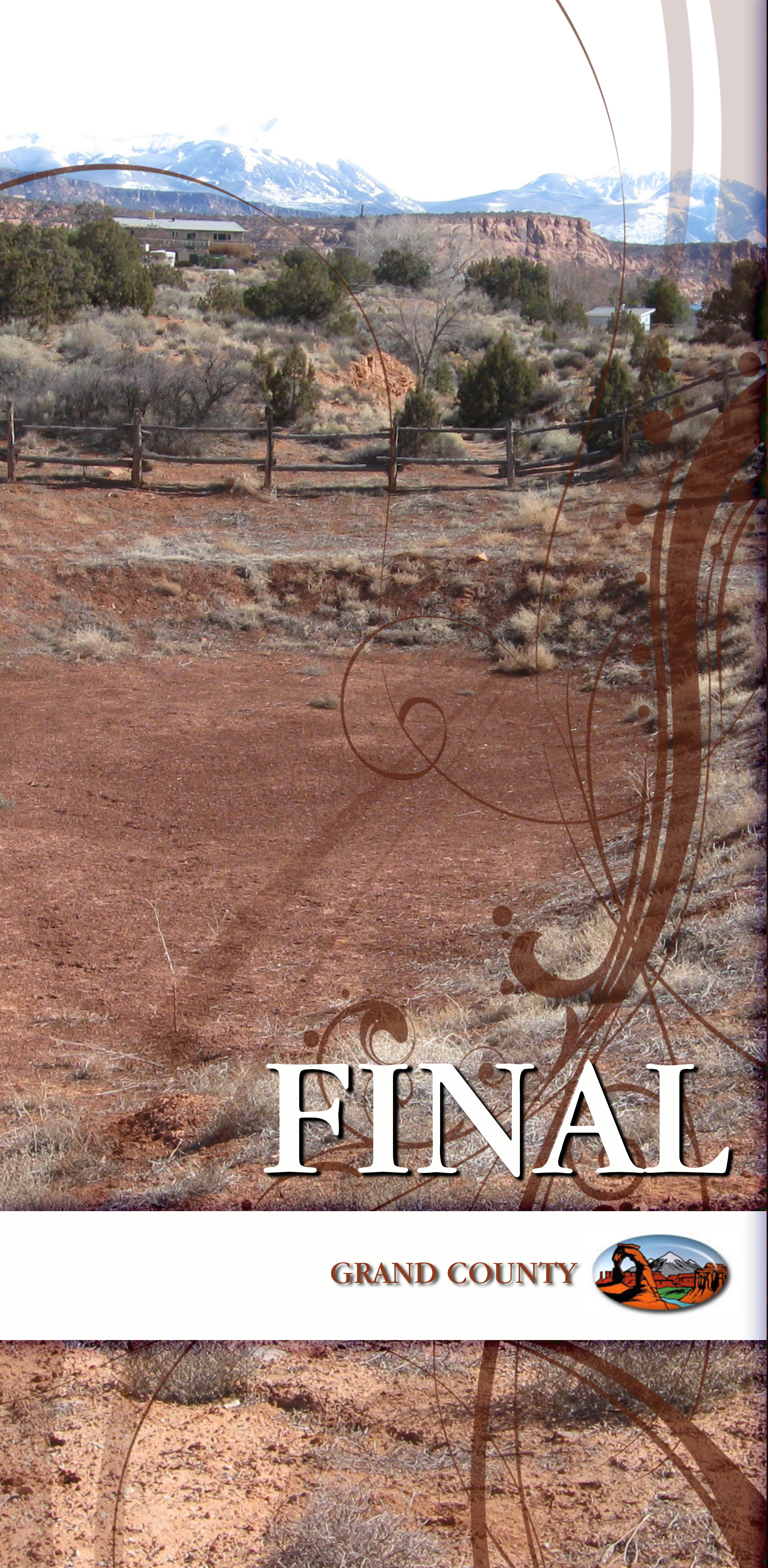

FINAL

DECEMBER 2011

SPANISH VALLEY STORM DRAIN MASTER PLAN UPDATE

GRAND COUNTY

HORROCKS ENGINEERS

SPANISH VALLEY STORM DRAIN MASTER PLAN UPDATE

DECEMBER 2011

Prepared for
Grand County

Grand County
UTAH

By
Horrocks Engineers

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12/9/11
STATE OF UTAH

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EXECUTIVE SUMMARY

The Spanish Valley in Grand County is experiencing a rapid change from an agricultural community to a commercial and residential center. This change has brought with it the pains associated with rapid growth. One of these pains is the realization of certain inadequacies in the existing storm water management plan.

Historically, Grand County has not had to concern itself with managing stormwater runoff because the historic drainage ways managed most of the water with little impact on the valley residents. When a large storm was encountered, localized flooding was not much of a problem because it was usually contained to fields and historic drainage ways.

The rapid development of the county has caused a need to re-evaluate the system and establish a plan and level of service to manage stormwater. A developed environment experiences significant damage when any level of flooding occurs. This environment also causes an increase in the amount of storm water that runs off a given area. Development also directly impacts the historic drainage ways with culverts, roads and structures, which cause new restrictions and flow path changes. The historic and increased runoff need to be contained and conveyed in a manner that protects the developed environment. For this reason, an updated Master Storm Water Management Plan was developed.

A level of service that plans for the 100-year rainfall event has been outlined. The existing and future needs of the Valley have been evaluated with respect to this level of service. Improvements have been recommended and prioritized, and funding alternatives have been investigated.

The following recommendations are made:

- Adopt this *Spanish Valley Storm Drain Master Plan Update*.
- Adopt the design standards and criteria per the *Grand County Design Criteria for Drainage Studies Within Spanish Valley.*
- Protect historic drainage ways and use these waterways as the stormwater conveyance facilities. This would require improvements as outlined in Figures 2-2 to 2-30. The improvements outlined in these figures would correct deficiencies in the existing management system in order to provide the level of service recommended.
- Tributary flood plains outlined in the *Spanish Valley Flood Plain Delineation* report, dated November 1995, be abolished as their respective improvements are installed and drainage easements are established.
- It is recommended that Grand County establish a clear funding mechanism to pay for the on-going operations and maintenance costs of the storm water system.

- It is recommended that Grand County perform an Impact Fee Analysis and comply with other requirements of the Utah Impact Fee statute in order to update its current storm water impact fee. This will provide the County with the ongoing ability to fund capital storm drain improvements and assign fair and appropriate financial responsibility for those improvements.

Table 3-3 and Table 3-4 show the recommended storm drain improvements. Table 4-1 and Table 4-2 show the drainage improvements prioritization, while Table 4-3 shows the cost estimate summaries of the recommended drainage improvements. The proposed drainage improvements are shown in Figures 2-2 through 2-30.

1 INTRODUCTION

1.1 Background Information

Storm water runoff is a difficult resource to manage. In a dry climate such as Utah's, existing drainage ways are often dry and, to the inexperienced, may appear to be prime places to construct buildings. Unlike sanitary sewers and culinary water systems, there are no clearly defined minimum service requirements for storm water systems. Storm water flows are dependent on many complex time and spatially varied factors. Even a natural, undeveloped drainage system is not static. Urbanization compounds the problem and creates a need for a new drainage system with the basic goals of managing nuisance water, protecting development from damage, and protecting downstream waters from adverse quality and quantity impacts.

The Spanish Valley has several historic drainage ways that flow from the hills on each side of the valley to Pack Creek. Some of these drainage ways have been altered or removed over the years due to road construction, development and/or farming. Excess storm water has caused areas of localized flooding due to these changes in the natural drainage ways. In the past, this flooding has not caused significant damage due to the nature of the agricultural area. However, the construction of homes in some of these areas has increased the risk of significant damage due to flooding.

In addition, the U.S. Environmental Protection Agency (EPA) passed federal storm water regulations in 1990 that mandated that municipalities change their traditional storm water runoff management techniques. Historically, storm water management techniques have been comprised of facilities that would control the quantity of runoff to prevent flooding. The new regulations require certain municipalities to also address the impacts that storm water runoff would have on the water quality of the receiving waters. The future possibility that Grand County may be required to comply with EPA regulations requires that storm water plans and improvements include the ability to meet present and potential future water quality regulations. The EPA is currently drafting proposals that would amend the 1990 regulations and cause storm water to be managed for each drainage basin instead of each municipality.

The purpose of this study is to prepare a valley-wide Storm Drain Master Plan using standardized analytical procedures. This makes it possible to develop a list of drainage improvements that could be used as the foundation for a drainage needs plan. The improvements identified in this study will help protect areas in the valley from floods in the future.

This Storm Drain Master Plan recognizes that, with the uncertainty of predicting how growth and development will take place, planning for the future is a continuing process and not an end result. The drainage improvements presented in this report have incorporated all existing storm drain facilities and the facilities recommended in the *Spanish Valley Flood Plain Delineation* report dated November 1995. It proposes preservation and/or re-creation of basic historic storm water routing paths and conveyance facilities where practical. Guidelines for quantifying and routing storm runoff are given along with proposed locations and sizing of facilities.

1.2 Study Area

In a topographic context, the Spanish Valley and Moab Valley are connected forming a single long "valley" which is generally oriented in a north-west to south-east direction, located in the southern end of Grand County along U.S Highway 191. The topography on either side of this valley rises rapidly to rocky ridges and plateaus. Moab City is located in Moab Valley, which lies on the north-west end of the "valley" against the Colorado River. The Spanish Valley extends from the Moab Valley south-east into San Juan County. The indistinct boundary between Moab Valley and Spanish Valley is the valley narrowing at about the 4200 ft elevation contour just south of where Mill Creek enters the valley.

For the purposes of this study, the Spanish Valley refers to the areas in the "valley" which are within Grand County jurisdiction from about where 4th East crosses Pack Creek continuing south and east to the San Juan County line. The extent of the study area for the Spanish Valley Storm Drain Master Plan Update includes the area within the Spanish Valley and the upper reaches of the watersheds draining into Spanish Valley from the rocky ridges on either side.

1.3 Existing Facilities

Pack Creek is the major conveyance system in the study area, which flows through the Spanish Valley in a north-westerly direction to the Colorado River. The upper reaches of the Pack Creek watershed begin in the La Sal Mountains of San Juan County. Mill Creek is another major waterway which enters Moab City along the northern boundary of the study area. All of the drainage basins throughout the study area flow into Pack Creek, except two small drainage basins on the north end which flow north into Mill Creek. The Pack Creek drainage system is characterized by several road crossings, culverts and bridges.

The majority of the existing storm water management facilities consist of natural drainages, road-side ditches and culverts. Some of the more recently installed drainage facilities include storm drain trunk lines and detention basins. It appears that, until the last 10 to 15 years, many of these existing facilities were installed based on historic data or available materials without much engineering design consideration. There are many areas where the natural drainages have been obliterated, blocked or re-routed. This has caused areas of localized flooding. There are also places where the existing roads have caused localized flooding due to a lack of runoff consideration in the design of the vertical alignment. Along U.S. Highway 191, there are many areas where 4-wheeler trails have cut-off existing drainage channels and washes, causing drainage to be diverted and increased flooding to occur.

Since the *Grand County Storm Drainage Master Plan* dated May 1997, there have been several drainage improvements installed, including detention basins, culverts, and storm drain trunk lines. These facilities have been installed based on the information provided in the 1997 master plan, which used a 100-year 24 hour total precipitation value of 2.41 inches. Since the 1997 master plan, however, the National Oceanic and Atmospheric Administration (NOAA) have made more up-to-date precipitation estimates available through their *NOAA Atlas 14*. This study uses the updated 100-year 24 hour total precipitation value of 2.82 inches, as obtained from *NOAA Atlas 14*. Due to the greater precipitation value used in this current study, there are some recently installed drainage improvements that are undersized.

1.4 Purpose of Study

The primary purpose for this study is to update the *Grand County Storm Drainage Master Plan* prepared by Horrocks Engineers in May 1997. This study is limited to the same study area as before, specifically the Spanish Valley portion of Grand County as outlined in the Study Area section. Although the 1997 master plan included a drainage capital improvement plan, the scope of this study does not include such. Specifically, this report does or includes the following:

- Updates, as far as possible, all public and private improvements to the storm drainage system that are currently in place or planned.
- Detailed evaluation of drainage basins that have had significant drainage improvements or changes since the 1997 master plan was prepared – this includes all drainage basins due to the change in the precipitation value used.
- Establishes the 10-year historic flow rates throughout the study area and the 100-year design flows based on the existing (2009) conditions.
- Evaluation of the existing storm drainage system.
- Identifies and makes recommendations on needed drainage improvements.
- Prioritization and cost estimates of all recommended drainage improvements.
- Updated maps of the study area showing existing drainage facilities and recommended improvements.

In conjunction with this study, the specific design criteria for all drainage studies within the Spanish Valley have also been created in a separate document – the *Grand County Design Criteria for Drainage Studies Within Spanish Valley*. [This document is referred to within this study as the criteria used for evaluating existing and proposed drainage facilities.] The recommended drainage improvements identified in this Master Plan will resolve existing drainage problems as well as drainage problems that are predicted to occur as areas of the valley experience further development. The Spanish Valley Storm Drain Master Plan Update also provides a standard and basis by which proposed developments can be evaluated for potential impacts to the system. All drainage studies performed for the Spanish Valley area of Grand County shall conform to the methodology and parameters used in this Master Plan and to the criteria outlined within the *Grand County Design Criteria for Drainage Studies Within Spanish Valley* document of 2011.

It should be noted that this Master Plan is intended to be used as a planning document for recommended drainage improvements on a valley-wide level. The hydrologic and hydraulic analyses presented in this study are based on broad assumptions and large scale analysis techniques. Therefore, prior to the actual *construction or installation of drainage improvements, more detailed analysis and design on a case-by-case basis should be performed.*

The Pack Creek channel itself was not modeled or studied in this Storm Drain Master Plan Update. Modeling Pack Creek to determine deficiencies and needed improvements is a major task which is outside the scope of this study. Proposed improvements for Pack Creek identified in the *Spanish Valley Flood Plain Delineation* (1995) and the *Grand County Storm Drainage Master Plan* (1997) are labeled in Figures 2-2 through 2-30; however, prioritization and cost estimates were not given for these improvements. Pack Creek should be studied and modeled in the future in order to determine necessary improvements.

2 HYDROLOGY

The first step of a storm drain master plan is the hydrological analysis of the study area in order to obtain design flows and volumes for the drainage systems. This chapter will discuss the model parameters, land use and population parameters, and the results for the hydrologic analysis of the Spanish Valley models for the historic and existing conditions. All drainage studies within this study area – the Spanish Valley of Grand County – shall use the same methodology and parameters as presented here, unless stated otherwise within the *Grand County Design Criteria for Drainage Studies Within Spanish Valley* document, which shall be used for all design criteria for drainage studies and drainage designs.

2.1 Modeling Parameters

2.1.1 Methods and Parameters

The hydrology was modeled using the Army Corps of Engineers' HEC-HMS software program, based on the Natural Resources Conservation Service (NRCS) unit hydrograph and curve number method. The U.S. Army Corps of Engineers' *HEC-HMS* version 3.1.0 software program was used to model the drainage basin flow rates, as well as for pond and channel routing. Watershed Modeling System (WMS) 8.0 was used to delineate drainage basins and calculate composite curve numbers. A 5 meter Auto-Correlated Elevation Model, from the *Utah GIS Portal* website, was used as a digital elevation model (DEM) within WMS to delineate the drainage basins. Drainage basin delineations were compared and adjusted based upon 2 ft contour data used in the 1997 Master Plan model, as well as aerial images, also obtained from the *Utah GIS Portal* website. WMS was also used to determine the parameters needed to calculate lag time, including average watershed slope, and watershed hydraulic length. Lag time was calculated using the NRCS lag time equation, which uses the average watershed slope.

The NRCS lag time equation is appropriate due to the large scale of this study and since more site specific data are not available. However, prior to construction or installation of actual drainage improvements, additional analyses for individual watersheds based on more detailed equations for lag time may be appropriate.

2.1.2 Precipitation

The precipitation data was obtained from NOAA Atlas 14 (January 2009) via the National Oceanic and Atmospheric Administration's (NOAA) Precipitation Frequency Data Server (http://hdsc.nws.noaa.gov/hdsc/pfds/sa/ut_pfds.html). Precipitation values were obtained for several different points within the study area and then the weighted average was used. The precipitation values used for modeling the 10-yr and 100-yr 24 hour storms are the same as those given in *Grand County Design Criteria for Drainage Studies Within Spanish Valley* and are summarized in Table 2-1. The NRCS Type-II 24 hour rainfall distribution was used in this study, and is in fact used to represent the majority of the continental United States.

Table 2-1: Precipitation Values Summary.

Frequency	24 hour Precipitation
10-year	1.74 inches
100-year	2.82 inches

2.1.3 Monsoonal Rainfall Patterns

Monsoonal rainfall patterns are possible in the Spanish Valley, creating storms approaching from the south. This would result in higher peak runoff for drainage basins with their upper reaches toward the south, due to a shorter time of concentration. Drainage basins with their upper reaches toward the north would see a decrease in the peak runoff as compared to storms that occur over the entire drainage basin at once, due to a longer time of concentration. However, these types of storms are difficult to model. Furthermore, there are still possibilities for storms to approach from other directions. As an additional note, if a monsoonal storm is assumed to move at 25 mph, then it would take less than 5 minutes for the storm to move from the south end to the north end of even the largest drainage basin within the study area (aside from Pack Creek). Thus, the amount by which the time of concentration would be effected is likely within possible error of time of concentration calculations. Therefore, to maintain consistent modeling procedures throughout the Spanish Valley, all drainage basins will be modeled the same based on the assumption that precipitation occurs simultaneously across the entire valley, without the affects of monsoonal rainfall patterns.

No matter how the Spanish Valley is modeled, lower drainage basins will tend to have much less runoff per acre than the upper basins, especially for historic and existing conditions with open pervious areas. This is due to the fact that the lower basins are primarily Type A and B hydrologic soil groups, which have much higher infiltration rates and longer times of concentration than the upper basins, which are primarily Type C and D hydrologic soil groups.

2.1.4 Storage Basins Modeling

Regional detention basins in this master plan are sized based on the 100-yr 24 hour storm with existing (2009) development conditions. Maximum release rates from principal outlets are based on the historic peak flow rate from the 10-yr 24 hour storm. As outlined in the design criteria for Grand County, future developments are required to detain runoff from the developed condition 100-yr 24 hour storm to the 10-yr 24 hour historic peak flow rate. Furthermore, it is required that the maximum emergency spillway flows from local development storage basins do not exceed the existing 100-yr peak flow rate. Therefore, by sizing regional detention basins for the existing 100-yr runoff, they will have sufficient capacity for the developed 100-yr runoff routed over the emergency spillway of local detention facilities upstream. Conveyance structures downstream of detention basins must have sufficient capacity for the 100-yr peak flow routed over the emergency spillway without the principal outlets functioning, or the 100-yr peak flow routed through the principal outlet without entering the emergency spillway, whichever is greater when combined with downstream inflow hydrographs.

Required detention storage volumes are estimated with the linear approximation method from within PondPack version 10.1. This method assumes a linear increase in release rate from the time the inflow hydrograph plot starts to curve upward to peak outflow rate. However, this method tends to underestimate the required storage volume. By modeling a few of the detention basins, it was determined that, for the purposes of this study, more reasonable and conservative approximations are generally obtained by increasing the linear approximation by 15%. Therefore, the needed storage volume is estimated as the linearly approximated volume increased by 15%. The actual proposed storage volume is the needed storage volume increased by another 20% to account for volume reduction due to sedimentation. The Spanish Valley Storm Drain Master Plan map gives both of these volumes (the needed storage volume, followed by the proposed storage volume). Actual detention basins that are modified or constructed may require more or less storage volume than estimated. Prior to implementing any drainage improvements, detention basins will need to be designed based the site characteristics, actual geometry of the basin, dam height, outlet design, etc. based on the procedures and design criteria outlined in the *Grand County Design Criteria for Drainage Studies Within Spanish Valley*.

The storage capacity of existing regional detention basins were estimated based on available design plans, aerial images, and the 2 ft contour data used in the 1997 Storm Drain Master Plan model. Small local detention basins developed by individual developers were not included in the hydrologic model.

Where existing detention basins require improvements, it was assumed for modeling purposes that all additional storage needed will be added upstream of the existing dam without modifying the height of the dam structure. The assumed outlet size is based on the existing dam height (allowable headwater). For proposed detention basins where there is not an existing basin, it is assumed that the proposed dam height will be 8 ft to the crest of the spillway and 10 ft to overtopping. However, smaller detention basins modeled, 1 ac-ft or less, assumed a dam height of 6 ft. to spillway crest.

Detention basins will be proposed where existing ponds do not exist if the existing 100-yr peak flow rate exceeds the downstream capacity.

2.2 LAND USE AND POPULATION PARAMETERS

2.2.1 EXISTING CONDITIONS

Existing land use maps were generated in GIS, starting with land use maps obtained from webGIS (www.webGIS.com) and the current Grand County zoning map. The maps were combined and then modified based on aerial images and field observations in order to make them more representative of existing land uses. The existing conditions were determined to be a combination of desert shrub, agricultural, residential, industrial and commercial land uses. The existing conditions were determined to be primarily in a fair hydrologic soil condition, with a few areas in good or poor conditions.

2.2.2 FUTURE CONDITIONS

Future storm water runoff conditions in the Spanish Valley are dependent on the type and amount of land being used for different purposes. The change in land use usually causes more of the rainfall to run off of the land and less of it to infiltrate into the soil. Population growth within the county brings changes in land use from agricultural and arid range to commercial and residential. The amount of change that will occur depends on how quickly the land will be developed. The purpose for determining the future condition is to establish the quantity of storm water runoff that ultimately must be planned for in the County storm drain system. This section discusses the parameters and assumptions used in the determination of future land use conditions.

Population Projections

Population projections were used to determine how quickly the valley will be developed. Based on the Population Division of the U.S. Census, Grand County has a current estimated population of about 9,600 people. The largest incorporated community is the City of Moab, which has a current population of about 5,000 people. There are a few other smaller communities, such as Brendal and Thompson Springs, in the County with very small populations. The area with the largest population in the County after the City of Moab is Spanish Valley, which is unincorporated. This area lies adjacent to and south of Moab in Grand County and has been growing at a slightly faster rate than Moab. It is assumed that the "Balance of County" population resides primarily in the Spanish Valley area. In making that assumption, the current population estimate for Spanish Valley is about 3,900 people.

Grand County population estimates and projections are given in Table 2-2. The2000, 2006, and 2008 population numbers are estimates provided by the Population Division, U.S. Census. The 2010, 2020, and 2030 projections were obtained from the 2008 Baseline City Population Projections, Governor's Office of Planning and Budget.

Table 2-2: Grand County Population Projections

	2000 Census	2006 Estimated	2008 Estimated	2010 Projected	2020 Projected	2030 Projected
Grand County	8,485	9,257	9,589	9,693	11,007	11,827
Castle Valley Town	349	375	386	391	444	477
Moab City	4,779	5,018	5,121	5,237	5,946	6,388
Balance of County	3,357	3,864	4,082	4,065	4,617	4,962

As far as future growth is concerned, the population for Grand County is projected to grow to 11,827 people by the year 2030. Moab is projected to have 6,388 people, and the "Balance of County", or Spanish Valley, is projected to have a population of 4,962 people by 2030.

The annual growth rate for Grand County, Utah as a whole is projected to be about 1 percent through 2030, which is below average when compared to the state as a whole. The state is projected to grow at an annual rate of about 2 percent during that same period.

Conditions at Ultimate Build-Out

The conditions at ultimate build-out were determined by the current zoning map of the Spanish Valley provided by Grand County. It was assumed that the entire valley would be developed at build-out and that the zoning and projected land use would not change.

Land Use Map for Build-Out Conditions

A zoning map was provided by Grand County to reflect the current zoning of the Spanish Valley. This map was used to determine the future locations of commercial, industrial, and residential development. If at any time the land use and/or zoning changes, the future runoff estimates may need to be updated to reflect actual conditions. Developed land use maps were obtained by modifying the Grand County zoning map to include existing land use in the areas outside of the zoning map boundary. Also, the developed land use map was changed to include the existing golf course, which is currently zoned as residential. For estimating curve numbers, it was assumed that the pervious areas of developed land use would approximate a desert shrub in good hydrologic soil condition.

2.3 Hydrologic Soil Groups

Hydrologic soil group types were used to determine NRCS curve numbers, which were then used for runoff calculations. Soils data was obtained from the NRCS Soil Survey Geographic (SSURGO) Database via the Soil Data Mart (http://soildatamart.nrcs.usda.gov/) for the Canyonlands Area of Utah, which includes parts of Grand and San Juan Counties. A hydrologic soils group map was generated based on attributes found in the RUSLE2 Related Attributes Report for the survey area. For map units with more than one soil type and hydrologic soil group, a single hydrologic soil group was assigned based on a weighted average by percentage of area. Soils named “Badland” and “Gullied land” were assigned a hydrologic soil group of D and gravel pits were assigned a hydrologic soil group of A. A map of the hydrologic soil groups for the Spanish Valley is shown in Figure 2-1.

2.4 Hydrologic Model

The existing conditions were modeled for the Spanish Valley to determine the effectiveness of the current storm water conveyance system based on the 10-yr and 100-yr storms. The historic conditions were also modeled with the 10-yr storm to determine the required release rates from detention basins.

All future developments are required to detain post-developed flows to 10-yr historic peak flow rates with emergency spillway flows of local storage basins not exceeding the 100-yr existing flow rates. Therefore, future flows should not exceed existing 100-yr flows downstream of developments. Thus, all proposed improvements in this Storm Drain Master Plan are based on 100-yr 24 hour storm with existing land use conditions. Proposed improvements downstream of storage basins will be based on the assumption that all proposed storage basins improvements are in place. As described previously, proposed conveyance system improvements downstream of storage facilities will be based on the greater peak flow obtained from the 100-yr hydrograph routed through the principal outlet or the 100-yr hydrograph routed over the emergency spillway.

Figures 2-2 though 2-30 show the existing and proposed drainage system and structures with three different flow rates: the first is the peak 10-yr historic flow rate, the second is the peak existing 100-yr flow rate routed through the principal outlet of proposed detention basins, and the third is the peak existing 100-yr flow rate routed through the emergency spillway of proposed detention basins. These three flow rates are given for the following reasons:

- The 10-yr historic flow rate is used to verify required storage basin release rates.

- The two different 100-yr flow rates are used for designing detention basins and the greater of the two 100-yr flow rates is used for sizing conveyance systems.

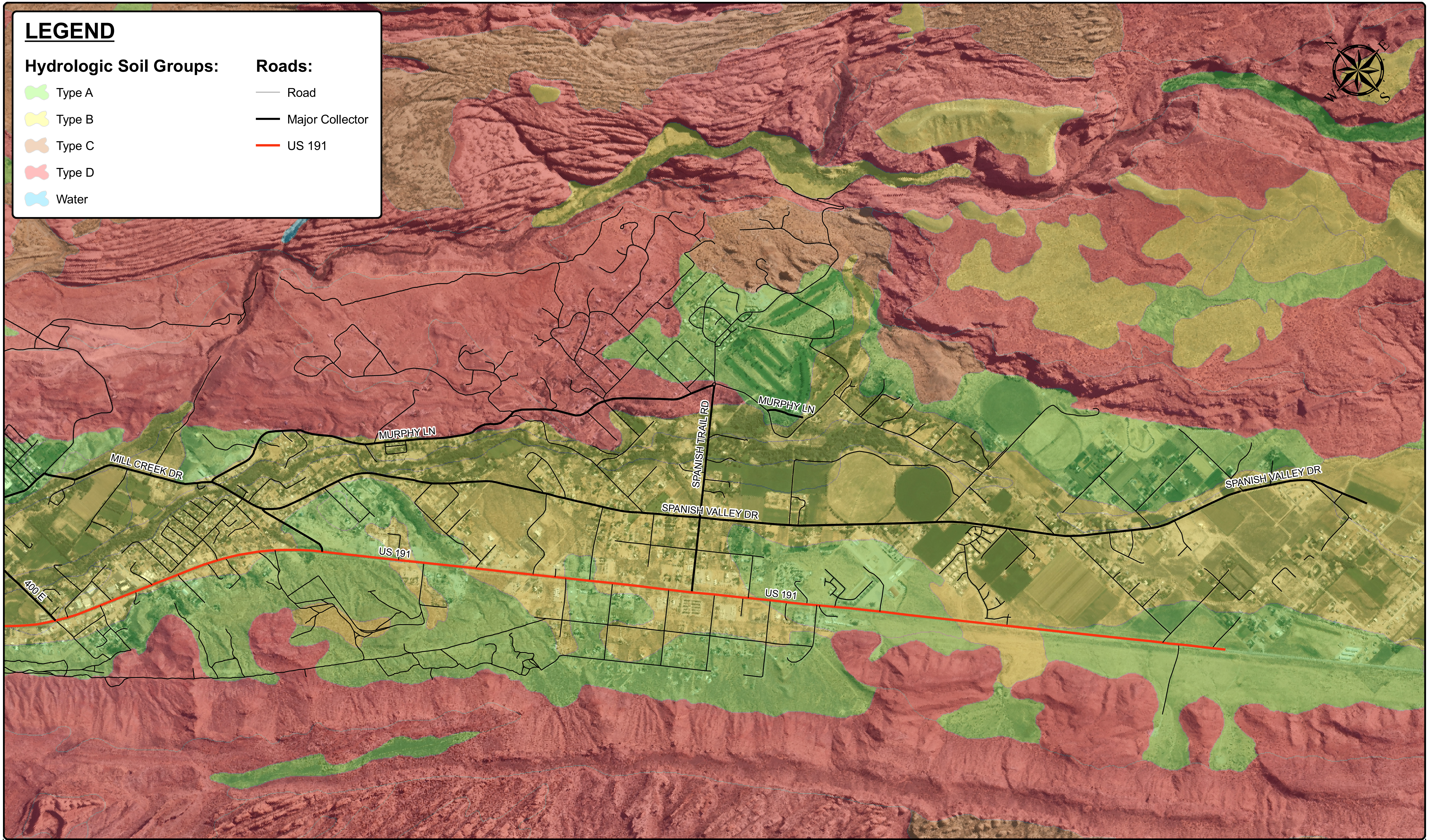
Locations with only two flow rates given include the peak 10-yr historic flow rate and the peak existing 100-yr flow rate without any detention basin routing.

2.5 KENS LAKE

Kens Lake is an irrigation reservoir owned by Grand Water and Sewer Service Agency (GWSSA), built in 1981. It has a total storage capacity to the spillway crest of 2,820 acre feet. It is located at the south end of Spanish Valley in San Juan County. It has a drainage basin area of approximately 3 square miles, which flows into Grand County. Kens Lake has a maximum outlet discharge of 135 cfs, most of which is generally diverted into an aqueduct for irrigation. Kens Lake has a maximum spillway capacity of 3,000 cfs, and a maximum dam breach flow of 64,000 cfs. A full breach analysis and inundation mapping have been performed by other agencies. This information, as well as other information regarding the dam, is available on the Dam Safety Database Information Viewer on the Utah Division of Water Rights website.

2.6 FLOWS ENTERING FROM SAN JUAN COUNTY

The calculation of flow rates entering Grand County from San Juan County is outside the scope of this study. However, some quick estimates of flows were performed. One method of estimating peak runoff flow rate is through the use of the regression equations and the basin delineation tools found on the USGS Utah StreamStats web site. This was performed to estimate the flow rate in Pack Creek and the channel below Kens Lake at the county line. The flows in Pack Creek at Mill Creek Drive were also estimated in order to compare them with the latest Flood Insurance Study FEMA flows reported in Pack Creek at Mill Creek Drive. It was found that these regression equation flows as determined on the USGS StreamStats web site were much different than both the FEMA flows and the flow rates reported in the previous (1997) Storm Drainage Master Plan. It was decided that the flow rates entering from San Juan County reported in the 1997 Storm Drainage Master Plan will be used for this report. Further study and analysis will need to be performed in order to update the flows for this portion of the Storm Drain Master Plan.



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SPANISH VALLEY

STORM DRAIN MASTER PLAN UPDATE

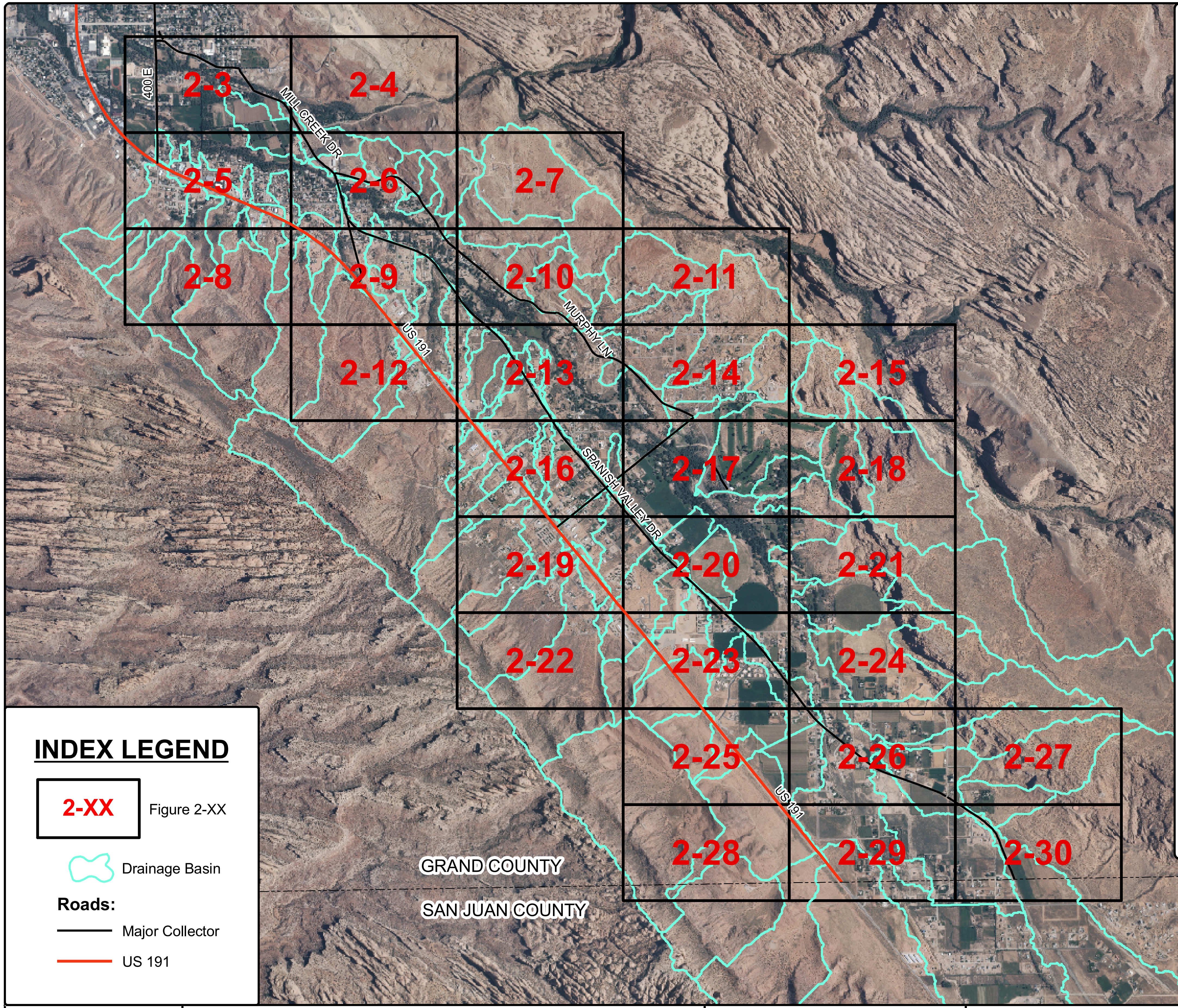
GRAPHIC SCALE

0 1,062.5 2,125 3,187.5 4,250 Feet

1 inch equals 2,125 feet

HYDROLOGIC SOIL GROUPS FOR SPANISH VALLEY

FIGURE 2-1



SHEET LEGEND

N W E S

- Existing Stream/Ditch
- Proposed Stream/Ditch
- Exist. Detention Basin
- Prop. Detention Basin
- Existing Culvert
- Proposed Culvert
- Existing Pipe
- Proposed Pipe
- Drainage Basin
- 10-ft Index Contour
- 2-ft Intermediate Contour

Pipe Labels:

XX" = Proposed Pipe Size
(XX") = Existing Pipe Size
X = Pipe/Drainage Network ID Labels

Detention Basin Labels:

Proposed Storage = XX ac-ft/XX ac-ft
= Needed storage/Proposed storage including 20% for sedimentation

Flow Labels:

XXB	Drainage Basin Label
XX cfs	10-yr Historic Flow
XX cfs	100-yr Existing Flow

XX cfs	10-yr Historic Flow
XX cfs	100-yr Existing Flow (P.O.)
XX cfs	100-yr Existing Flow (E.S.)

Notes:

10-yr Historic Flow = What the 10-yr storm flow would be before any development or detention basins were installed.
100-yr Existing Flow (P.O.) = The 100-yr existing flow routed though the Principal Outlet of upstream detention basins.
100-yr Existing Flow (E.S.) = The 100-yr existing flow routed through the Emergency Spillway of upstream detention basins (assuming the Principal Outlet is not functioning).

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SPANISH VALLEY
STORM DRAIN MASTER PLAN UPDATE

GRAPHIC SCALE
0 750 1,500 3,000 4,500 6,000 Feet
1 inch equals 3,000 feet

SHEET INDEX AND LEGEND

FIGURE 2-2

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SPANISH VALLEY
STORM DRAIN MASTER PLAN UPDATE

GRAPHIC SCALE
0 100 200 400 600 Feet
1 inch equals 300 feet

LEGEND
- Existing Stream/Ditch
- Proposed Stream/Ditch
- Exist. Detention Basin
- Prop. Detention Basin
- Existing Culvert
- Proposed Culvert
- Existing Pipe
- Proposed Pipe
- Drainage Basin

FIGURE 2-3

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SPANISH VALLEY
STORM DRAIN MASTER PLAN UPDATE

GRAPHIC SCALE
0 100 200 400 600 Feet
1 inch equals 300 feet

LEGEND
- Existing Stream/Ditch
- Proposed Stream/Ditch
- Exist. Detention Basin
- Prop. Detention Basin
- Existing Culvert
- Proposed Culvert
- Existing Pipe
- Proposed Pipe
- Drainage Basin

FIGURE 2-4

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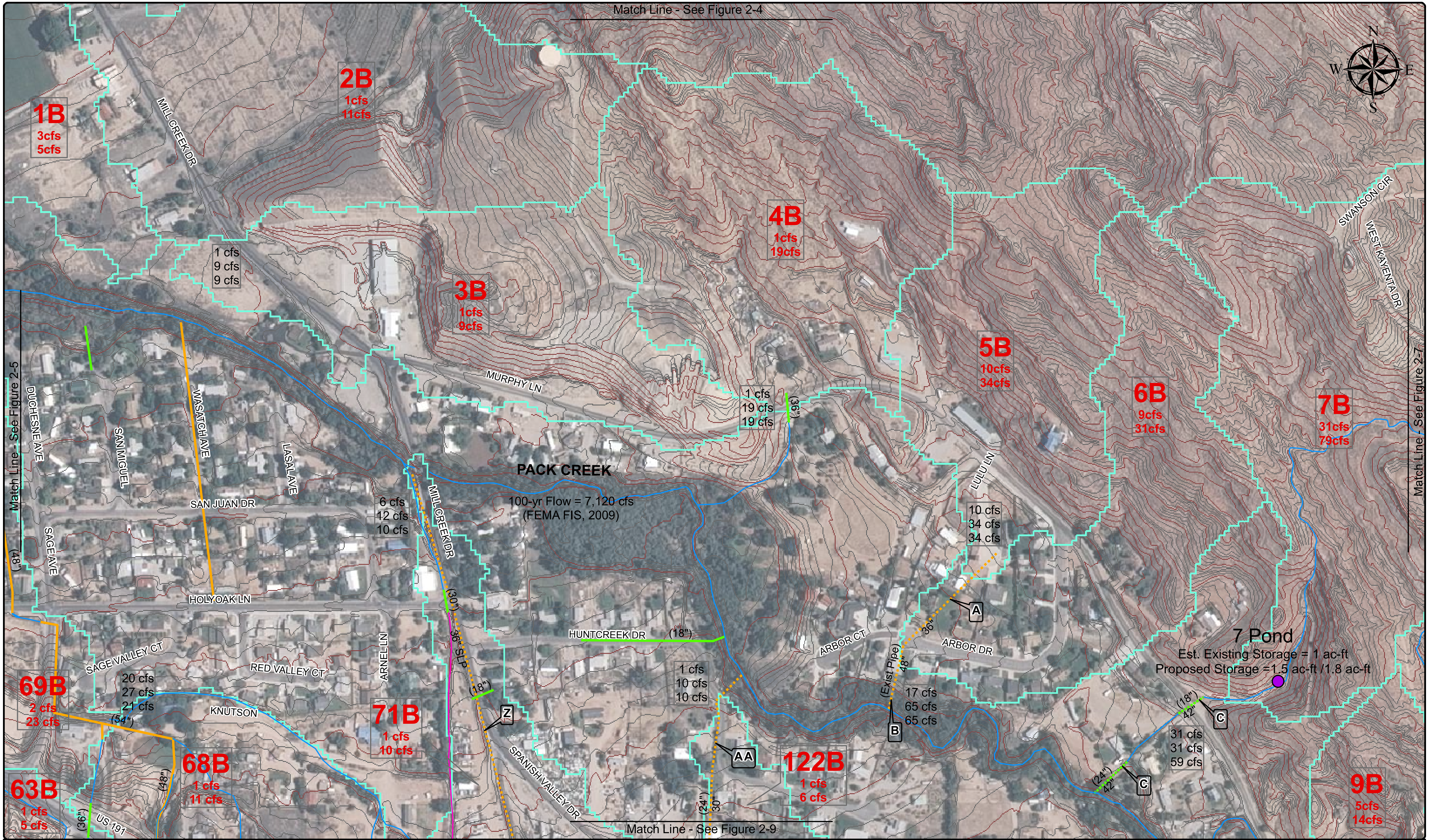
SPANISH VALLEY

STORM DRAIN MASTER PLAN UPDATE

GRAPHIC SCALE
0 100 200 400 600 Feet
1 inch equals 300 feet

LEGEND
- Existing Stream/Ditch
- Proposed Stream/Ditch
- Exist. Detention Basin
- Prop. Detention Basin
- Existing Culvert
- Proposed Culvert
- Existing Pipe
- Proposed Pipe
- Drainage Basin

FIGURE 2-5



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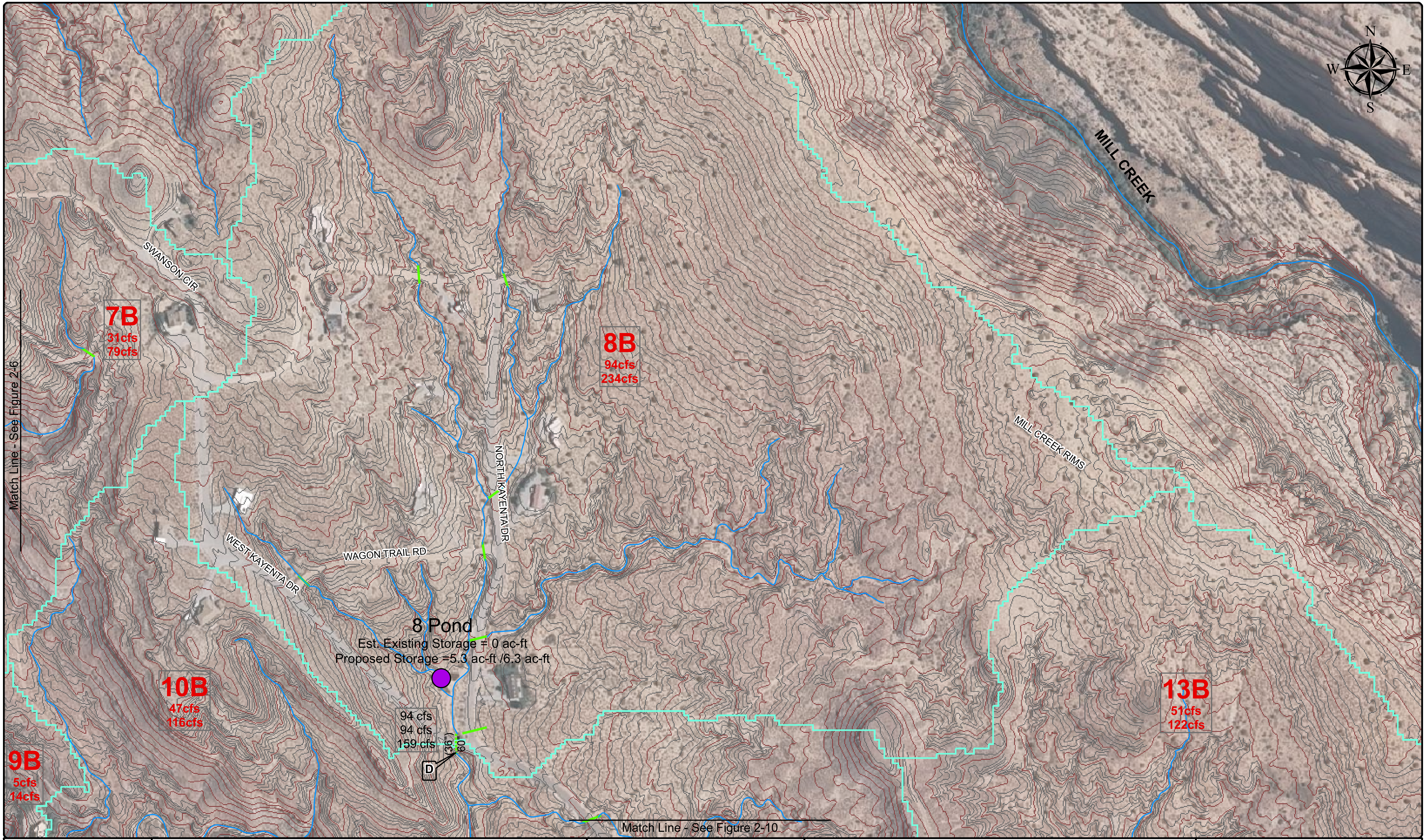
SPANISH VALLEY
STORM DRAIN MASTER PLAN UPDATE

GRAPHIC SCALE
0 100 200 400 600 Feet
1 inch equals 300 feet

LEGEND
- Existing Stream/Ditch
- Proposed Stream/Ditch
- Exist. Detention Basin
- Prop. Detention Basin
- Existing Culvert
- Proposed Culvert
- Existing Pipe
- Proposed Pipe
- Drainage Basin

FIGURE 2-6



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SPANISH VALLEY

STORM DRAIN MASTER PLAN UPDATE

GRAPHIC SCALE

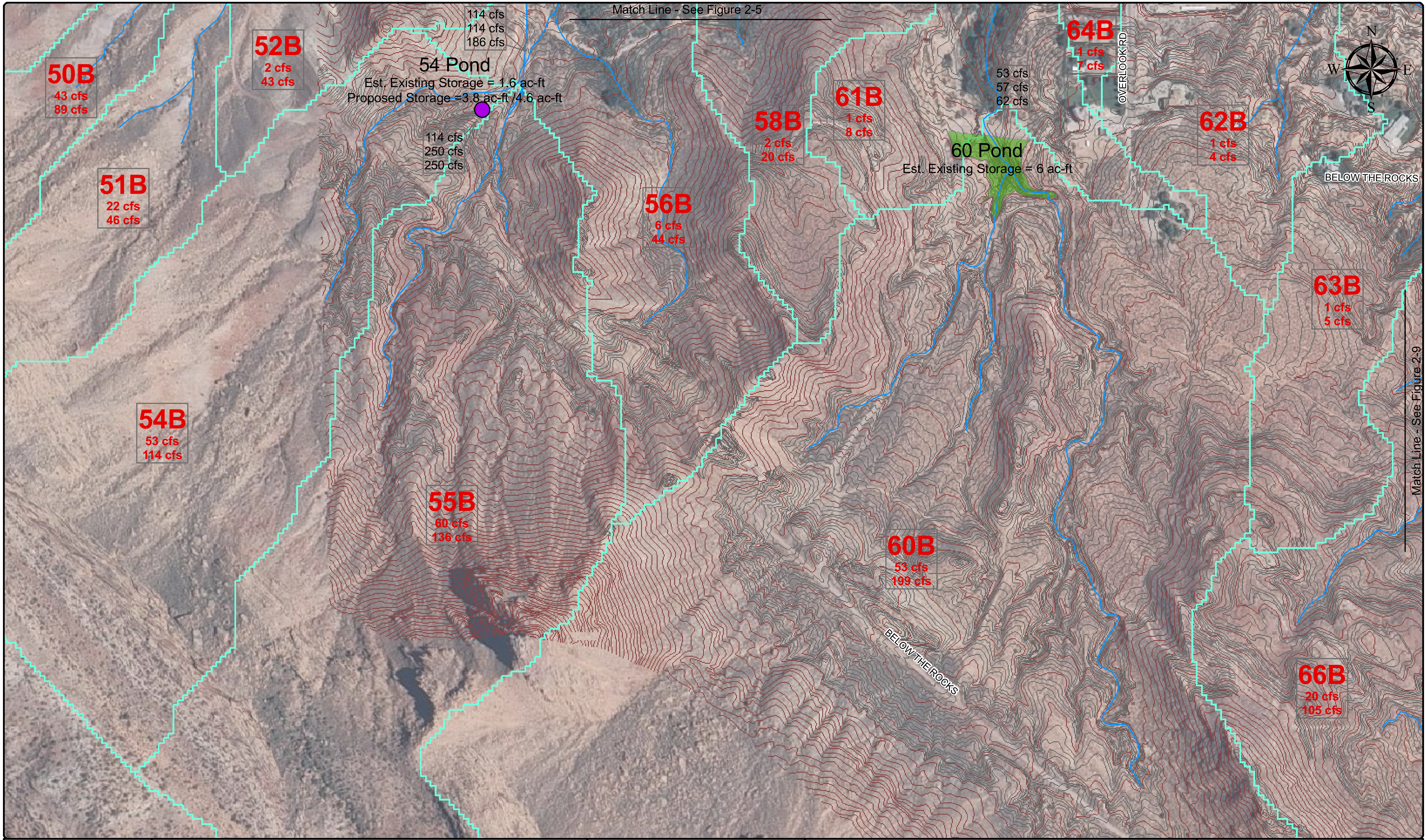
0 100 200 400 600 Feet

1 inch equals 300 feet

LEGEND

- Existing Stream/Ditch
- Proposed Stream/Ditch
- Exist. Detention Basin
- Prop. Detention Basin
- Existing Culvert
- Proposed Culvert
- Existing Pipe
- Proposed Pipe
- Drainage Basin

FIGURE 2-7



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STORM DRAIN MASTER PLAN UPDATE

GRAPHIC SCALE
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- Existing Culvert
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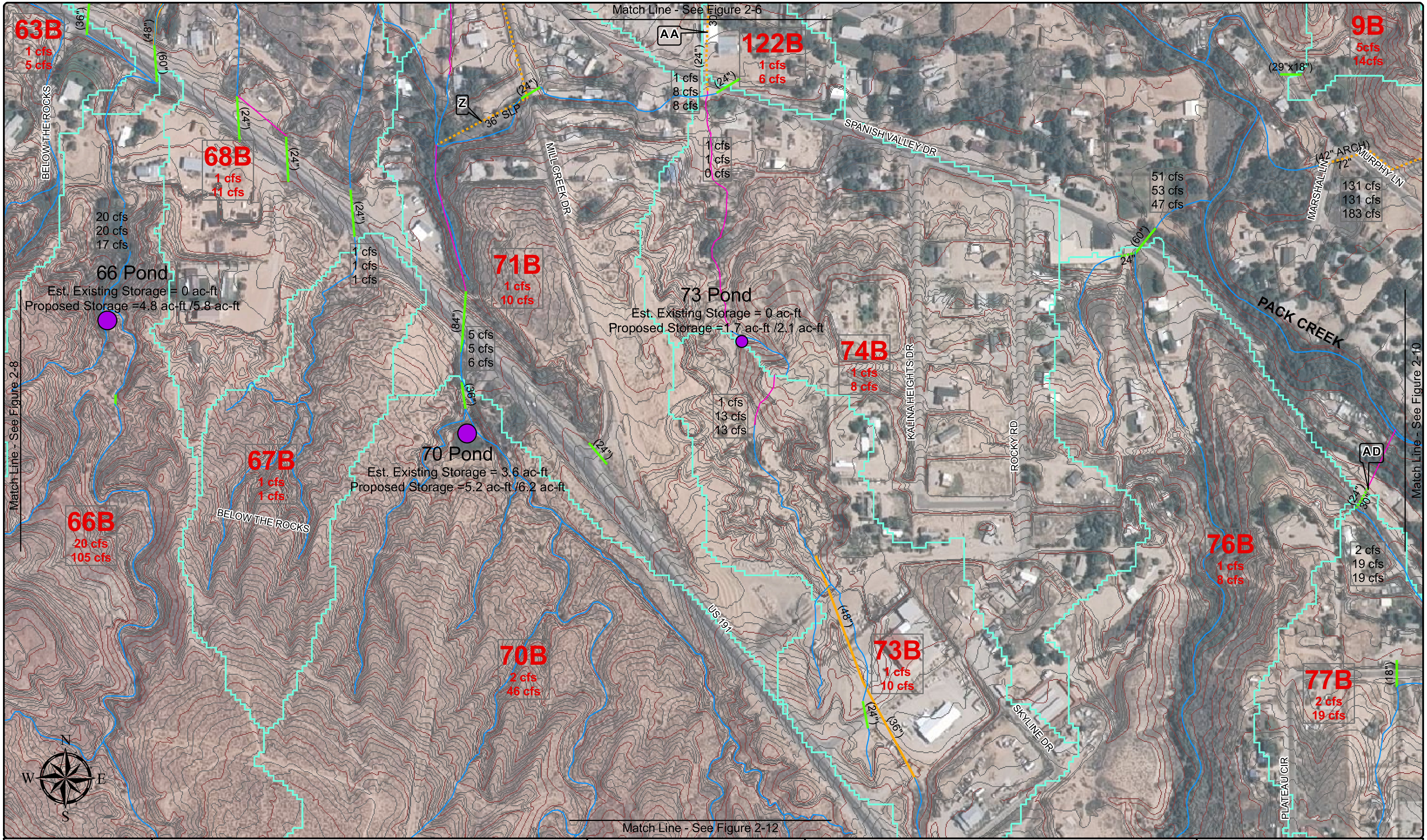
- Existing Pipe
- Proposed Pipe
- Drainage Basin

FIGURE 2-8



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STORM DRAIN MASTER PLAN UPDATE

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- Proposed Pipe
- Drainage Basin

FIGURE 2-9

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STORM DRAIN MASTER PLAN UPDATE

GRAPHIC SCALE

0 100 200 400 600 Feet

1 inch equals 300 feet

LEGEND

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- Proposed Stream/Ditch
- Exist. Detention Basin
- Prop. Detention Basin
- Existing Culvert
- Proposed Culvert
- Existing Pipe
- Proposed Pipe
- Drainage Basin

FIGURE 2-10

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GRAPHIC SCALE

0 100 200 400 600 Feet

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LEGEND

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- Proposed Stream/Ditch
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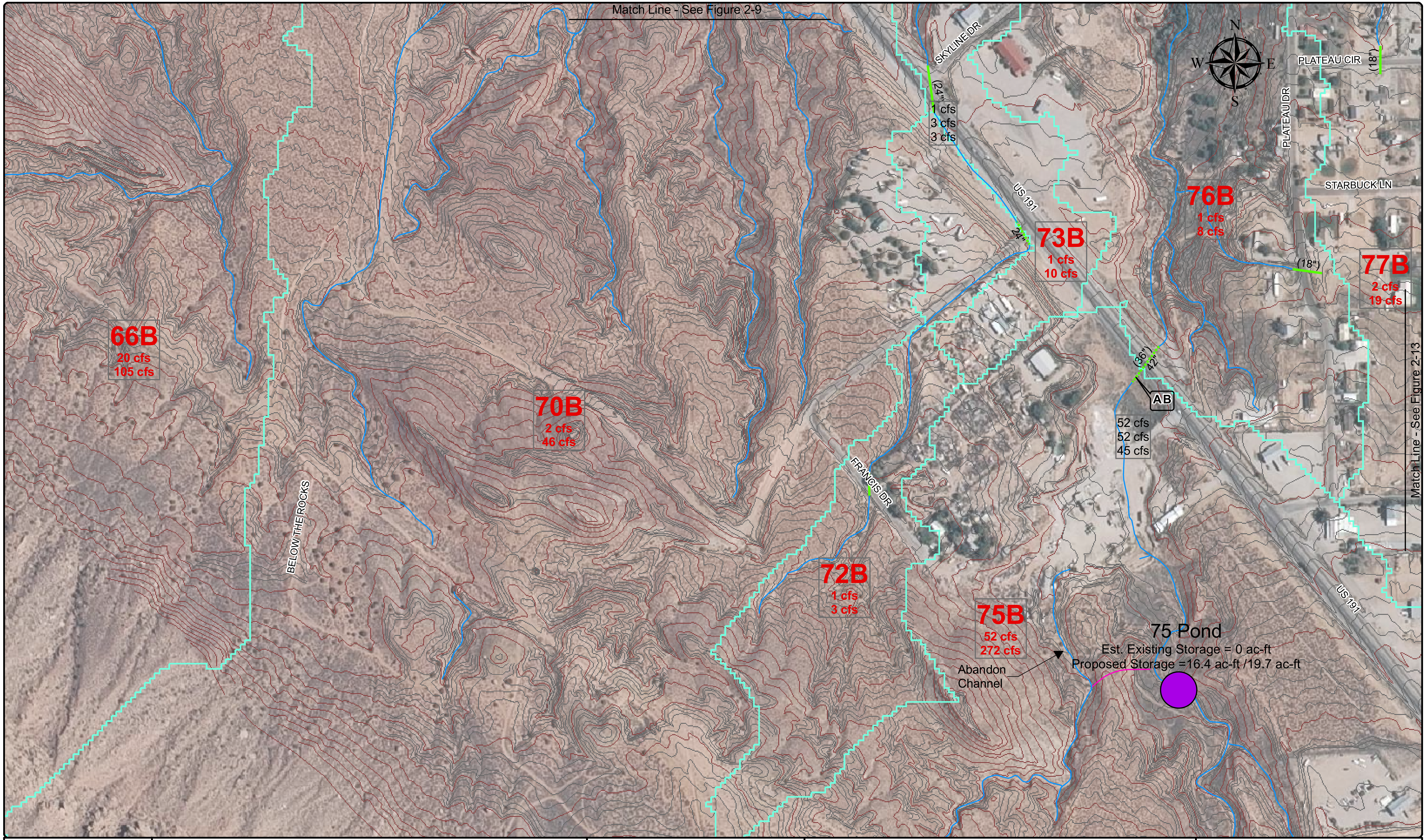
- Prop. Detention Basin
- Existing Culvert
- Proposed Culvert
- Existing Pipe
- Proposed Pipe
- Drainage Basin

FIGURE 2-11



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STORM DRAIN MASTER PLAN UPDATE

GRAPHIC SCALE

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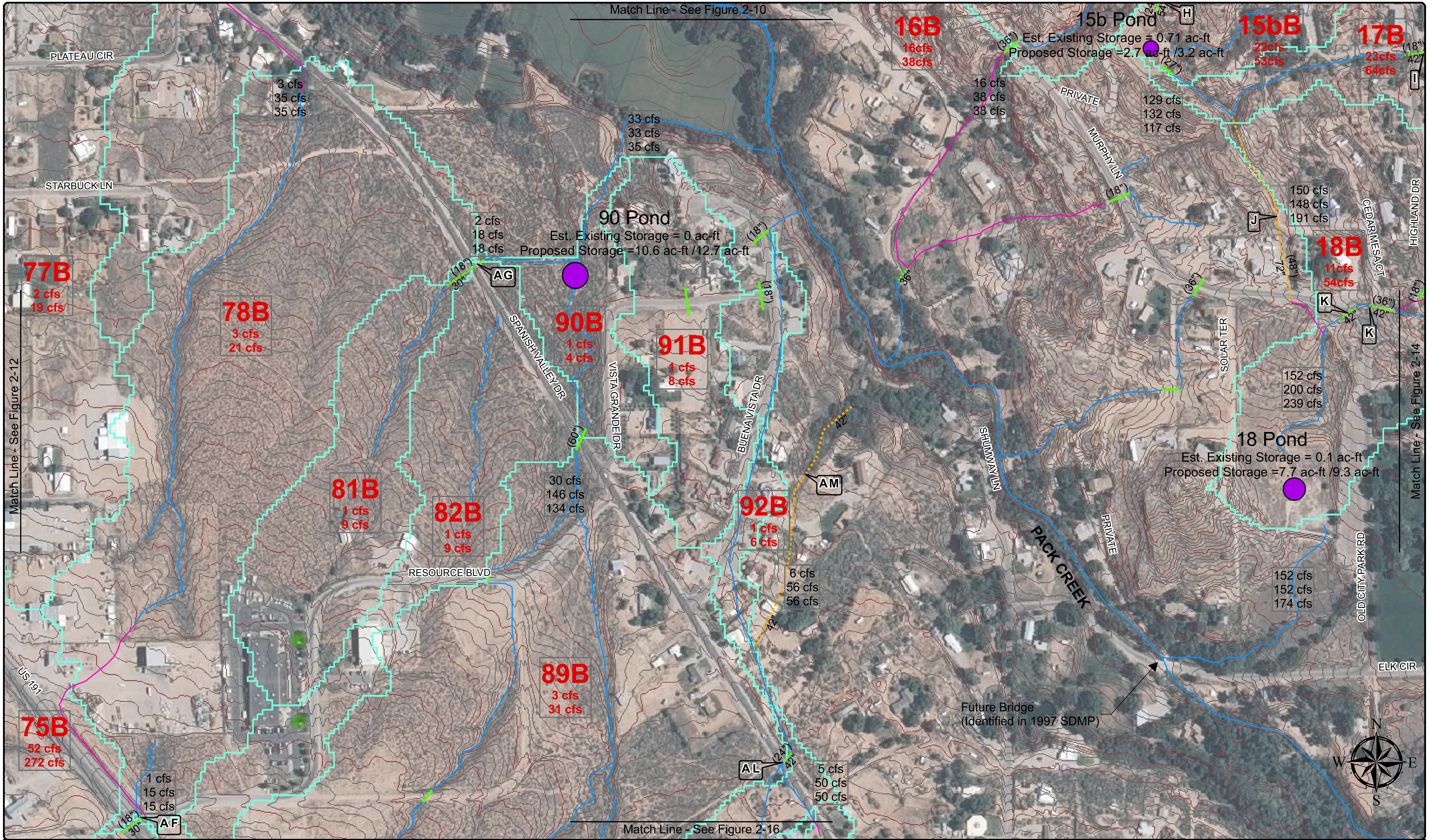
- Existing Pipe
- Proposed Pipe
- Drainage Basin

FIGURE 2-12



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STORM DRAIN MASTER PLAN UPDATE

GRAPHIC SCALE

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- Proposed Pipe
- Drainage Basin

FIGURE 2-13

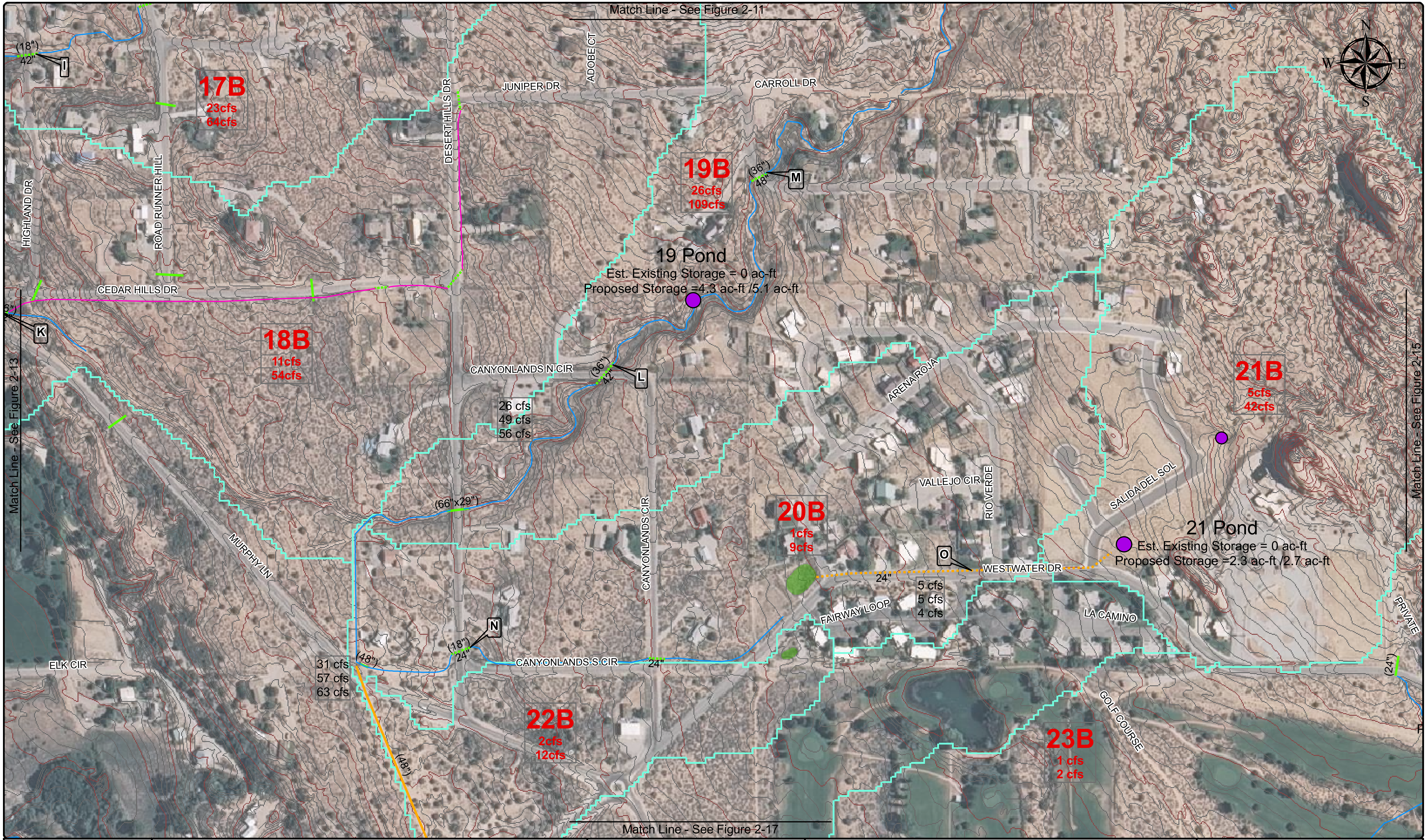

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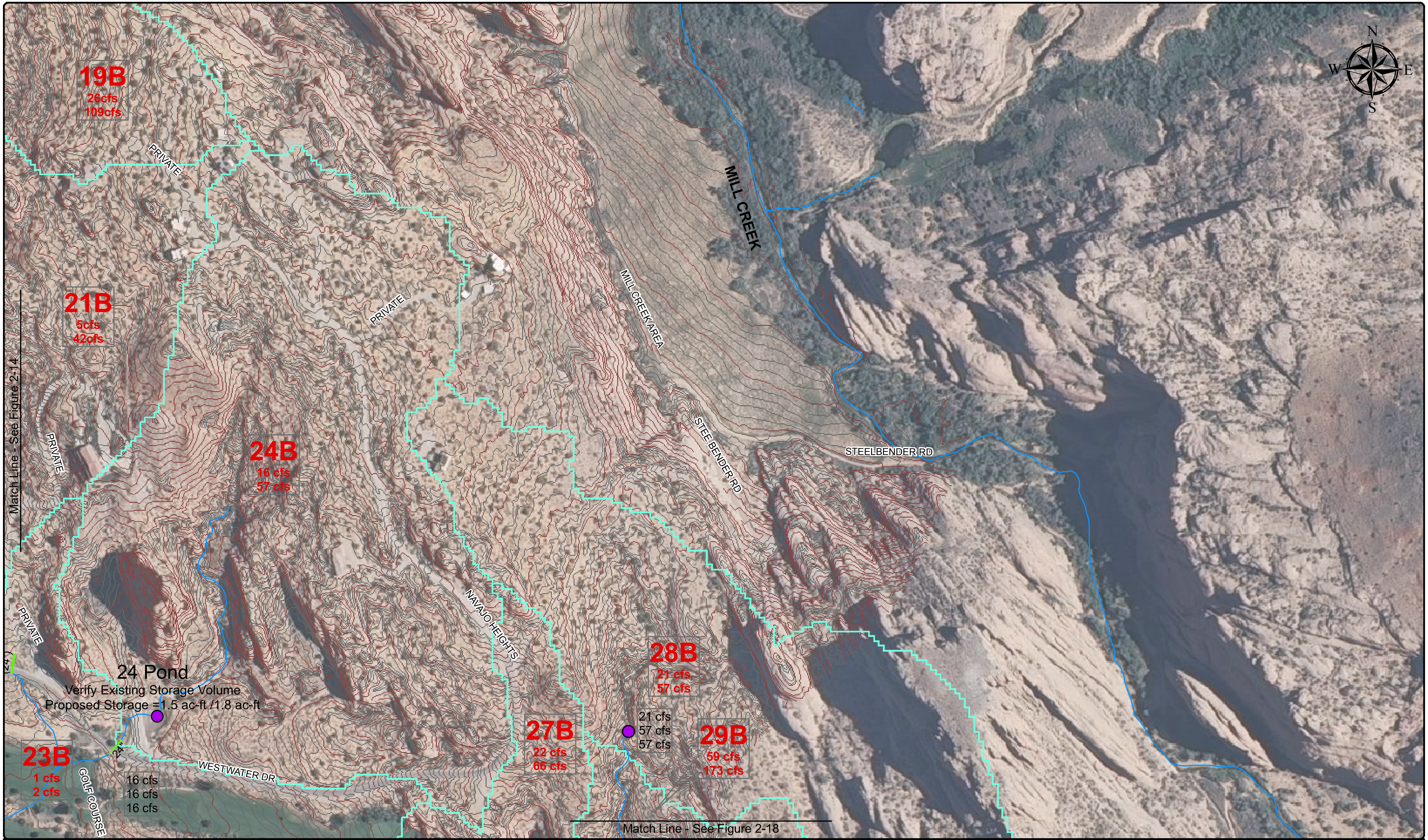
FIGURE 2-14



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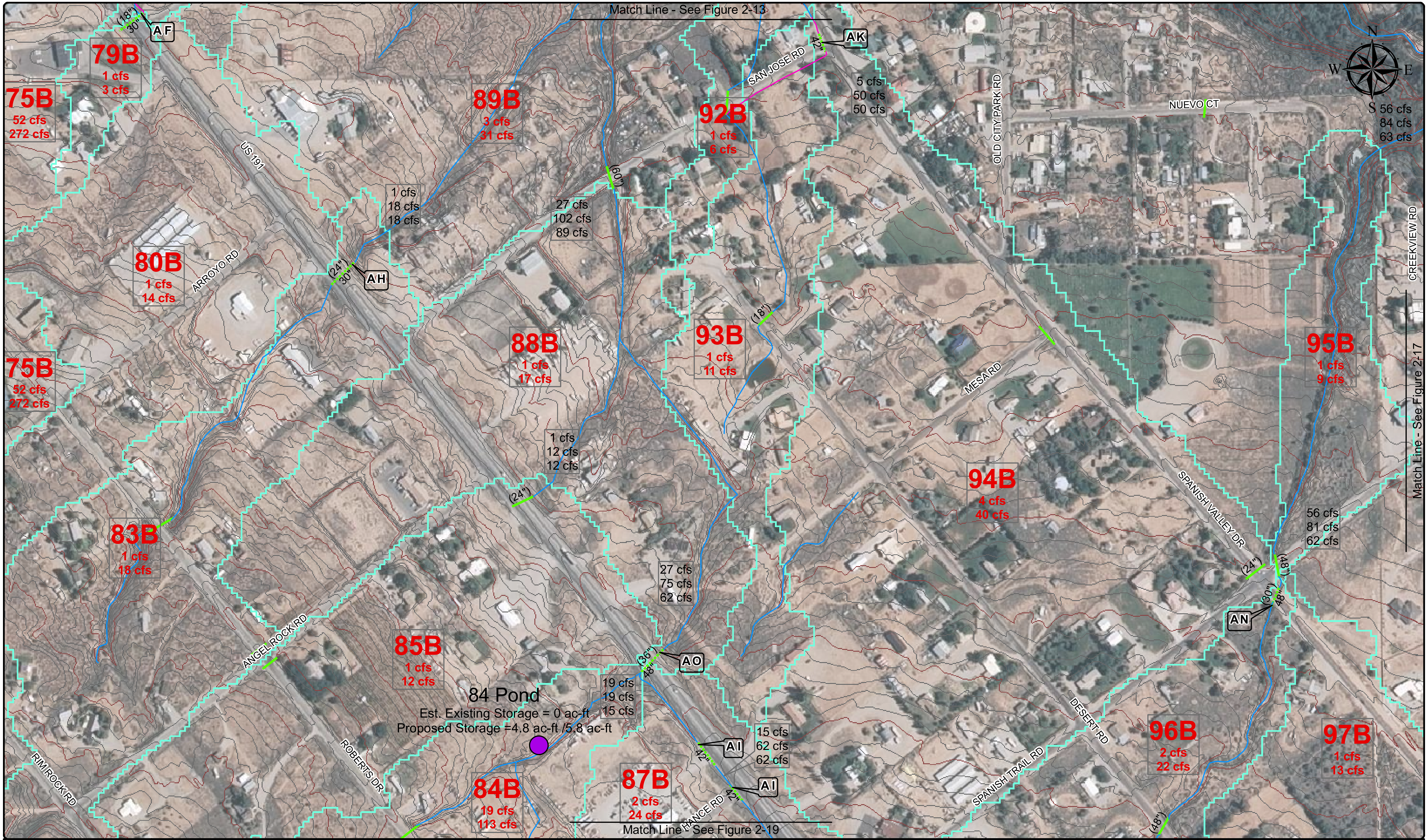
- Existing Pipe
- Proposed Pipe
- Drainage Basin

FIGURE 2-15



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STORM DRAIN MASTER PLAN UPDATE

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- Exist. Detention Basin
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- Proposed Culvert
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- Proposed Pipe
- Drainage Basin

FIGURE 2-16

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STORM DRAIN MASTER PLAN UPDATE

GRAPHIC SCALE
0 100 200 400 600 Feet
1 inch equals 300 feet

LEGEND
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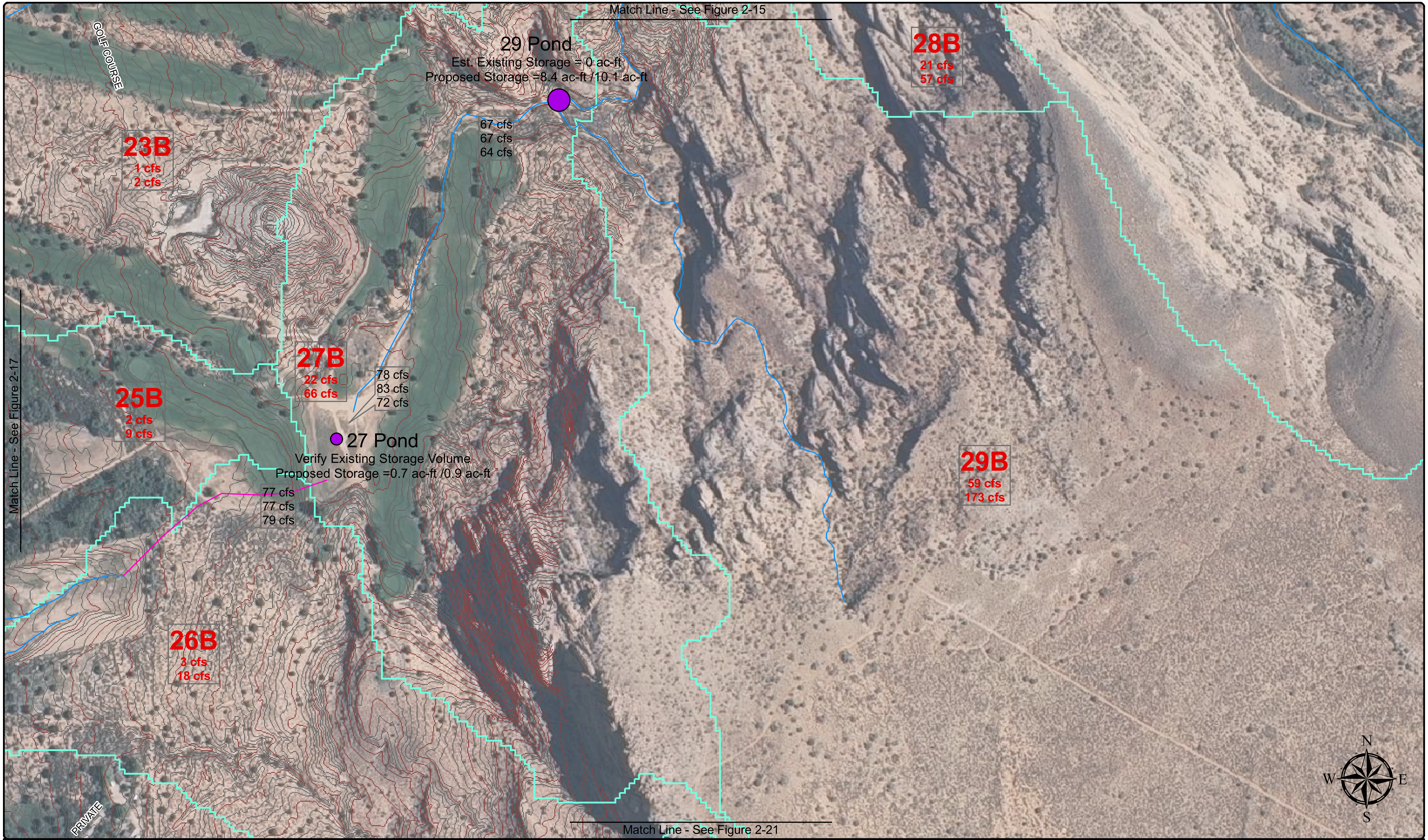
- Exist. Detention Basin
- Prop. Detention Basin
- Existing Culvert
- Proposed Culvert
- Existing Pipe
- Proposed Pipe
- Drainage Basin

FIGURE 2-17



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GRAPHIC SCALE

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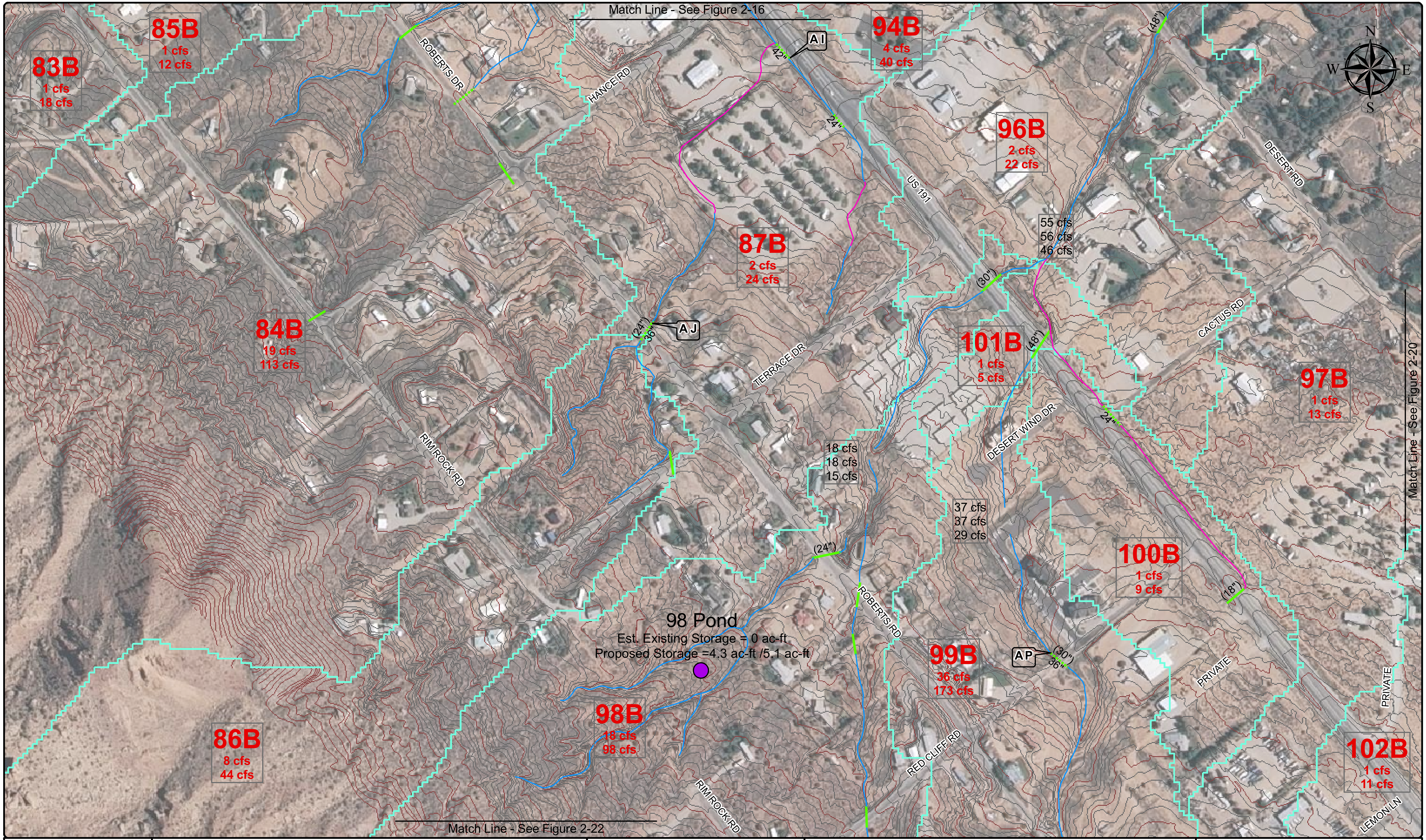
- Proposed Pipe
- Drainage Basin

FIGURE 2-18



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GRAPHIC SCALE

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- Existing Pipe
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- Drainage Basin

FIGURE 2-19

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STORM DRAIN MASTER PLAN UPDATE

GRAPHIC SCALE

0 100 200 400 600 Feet

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LEGEND

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- Exist. Detention Basin
- Prop. Detention Basin
- Existing Culvert
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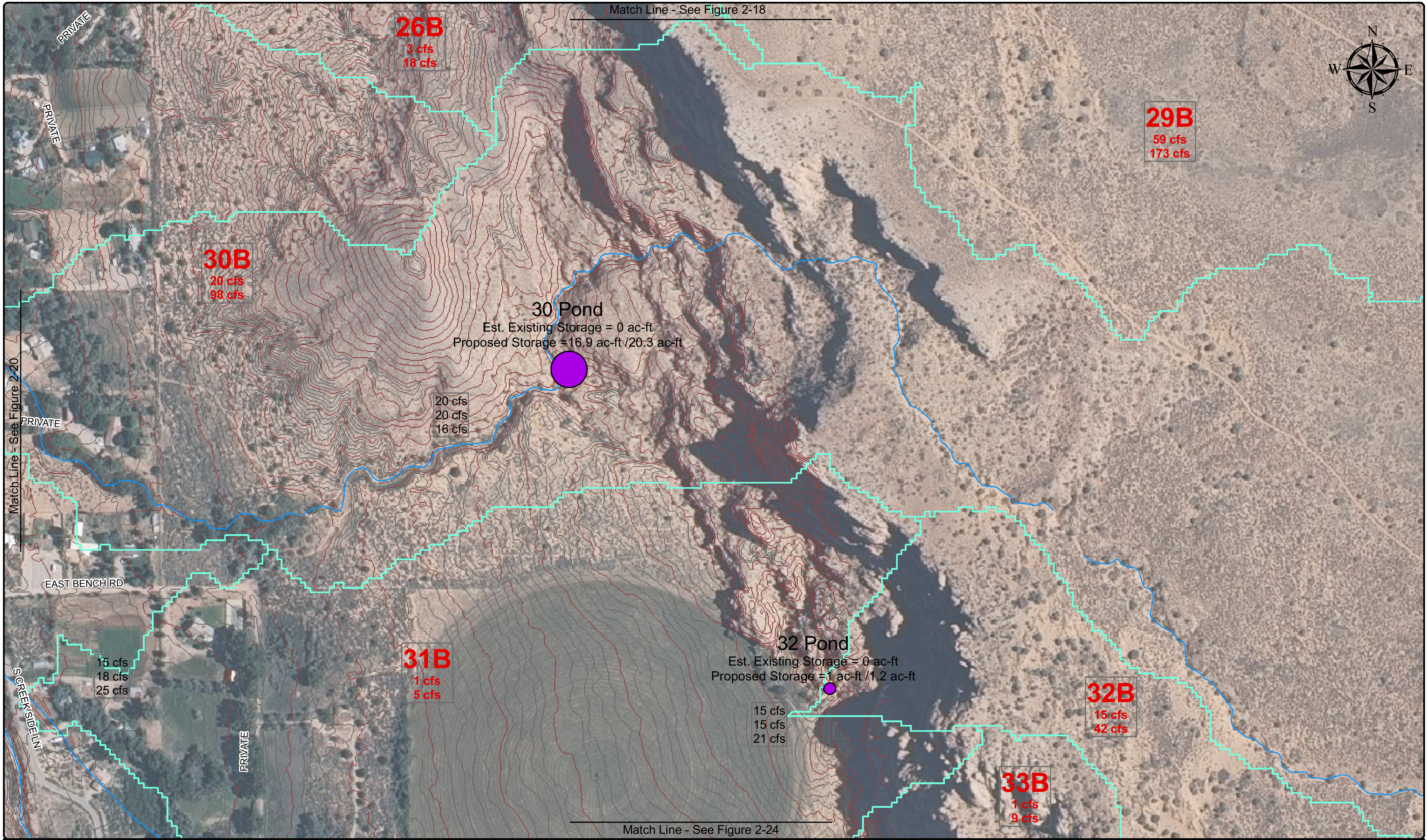
- Existing Pipe
- Proposed Pipe
- Drainage Basin

FIGURE 2-20



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STORM DRAIN MASTER PLAN UPDATE

GRAPHIC SCALE

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- Drainage Basin

FIGURE 2-21

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STORM DRAIN MASTER PLAN UPDATE

GRAPHIC SCALE
0 100 200 400 600 Feet
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LEGEND
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- Drainage Basin

FIGURE 2-22

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SPANISH VALLEY

STORM DRAIN MASTER PLAN UPDATE

GRAPHIC SCALE

0 100 200 400 600 Feet

1 inch equals 300 feet

LEGEND

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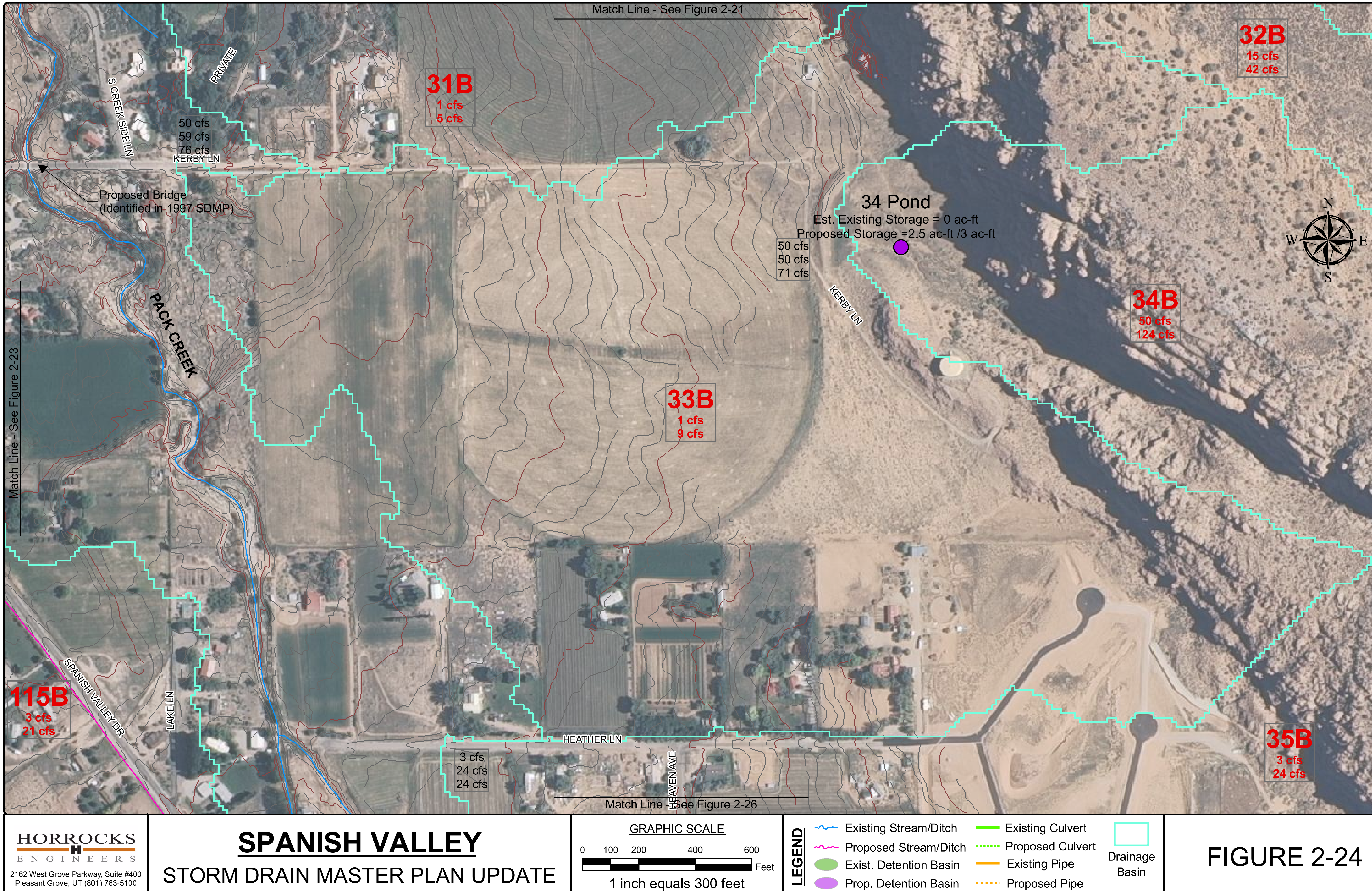
- Existing Pipe
- Proposed Pipe
- Drainage Basin

FIGURE 2-23



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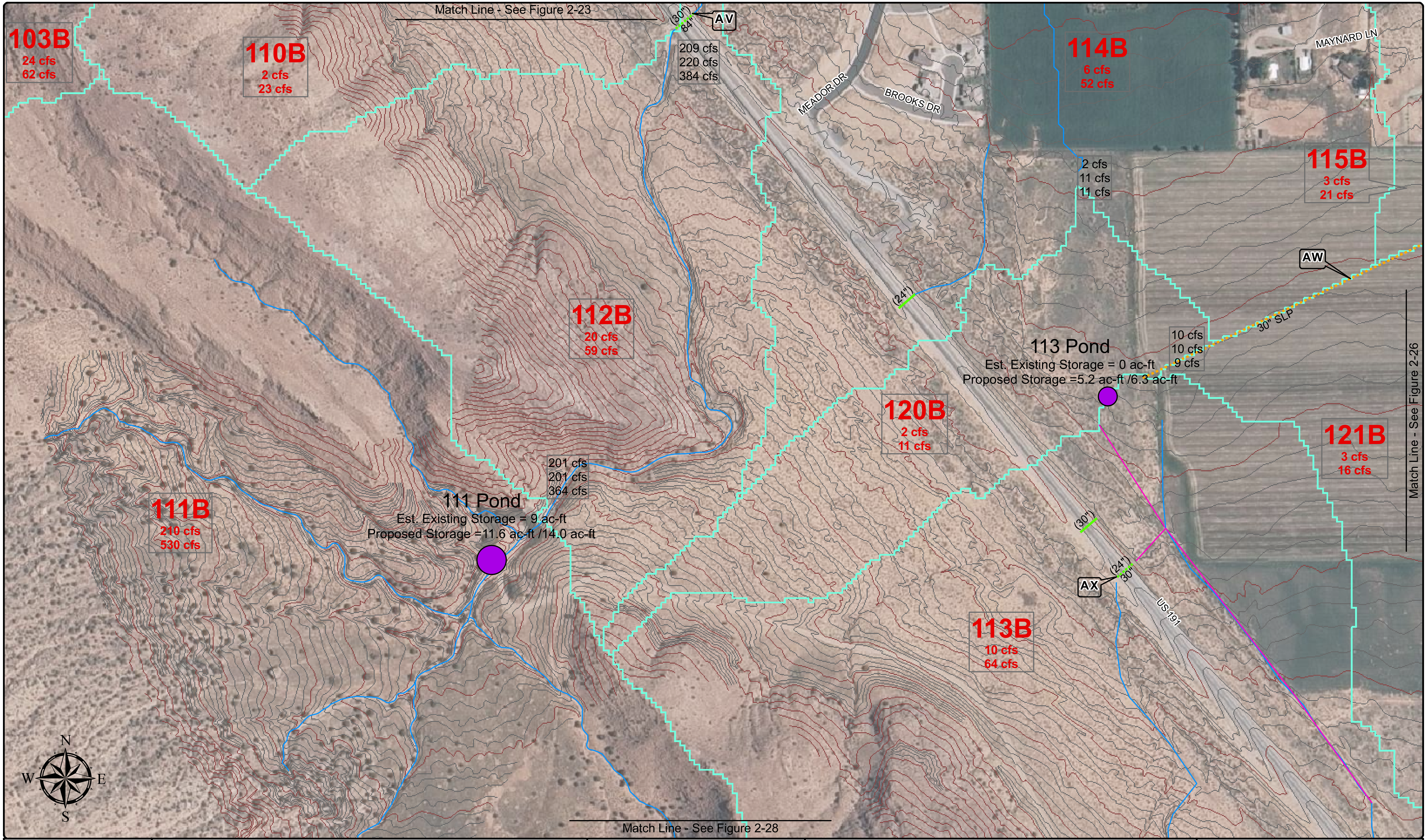
SPANISH VALLEY
STORM DRAIN MASTER PLAN UPDATE

FIGURE 2-24



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GRAPHIC SCALE

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LEGEND

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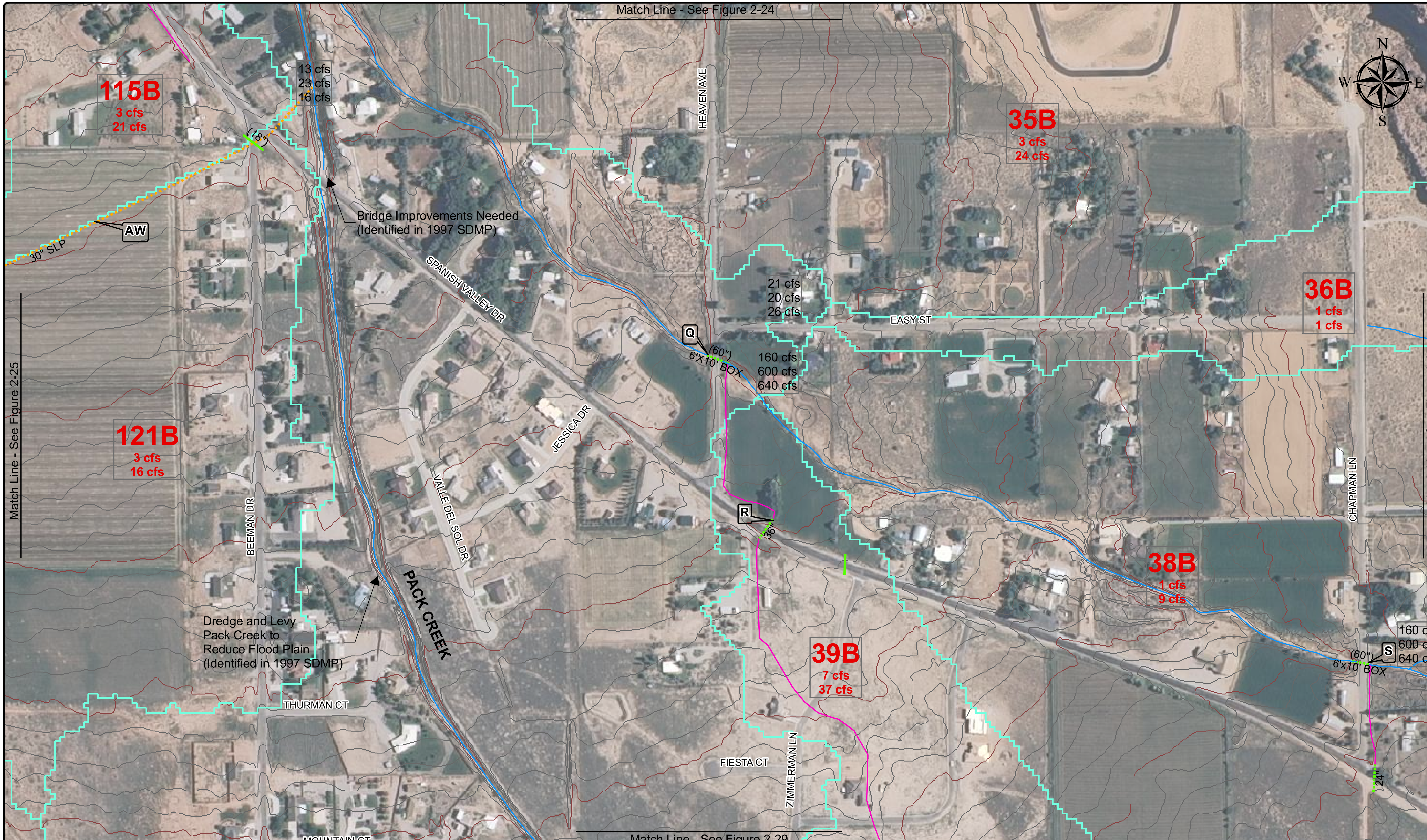
- Drainage Basin

FIGURE 2-25



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STORM DRAIN MASTER PLAN UPDATE

GRAPHIC SCALE
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LEGEND
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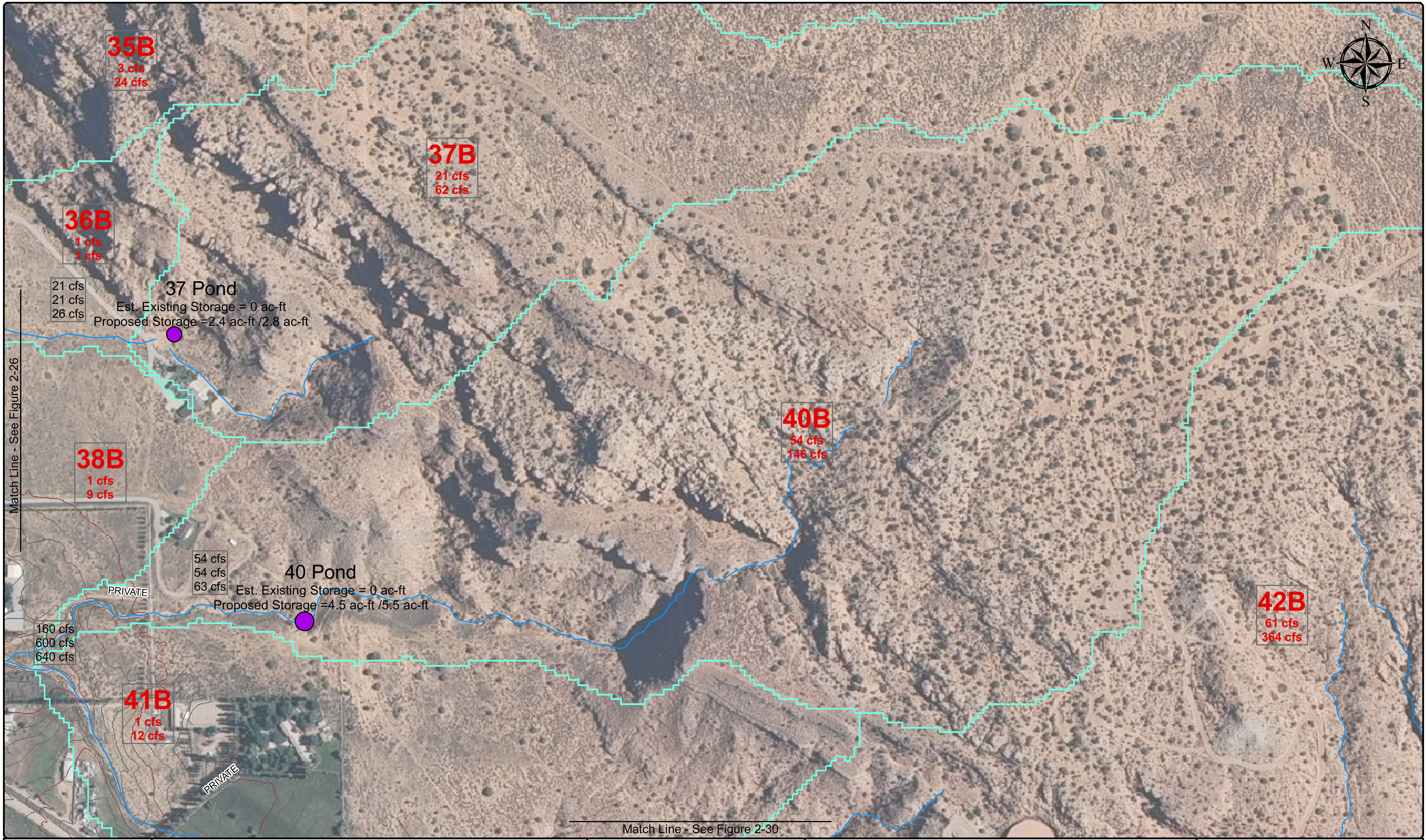
- Existing Pipe
- Proposed Pipe
- Drainage Basin

FIGURE 2-26



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STORM DRAIN MASTER PLAN UPDATE

GRAPHIC SCALE
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LEGEND
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- Prop. Detention Basin
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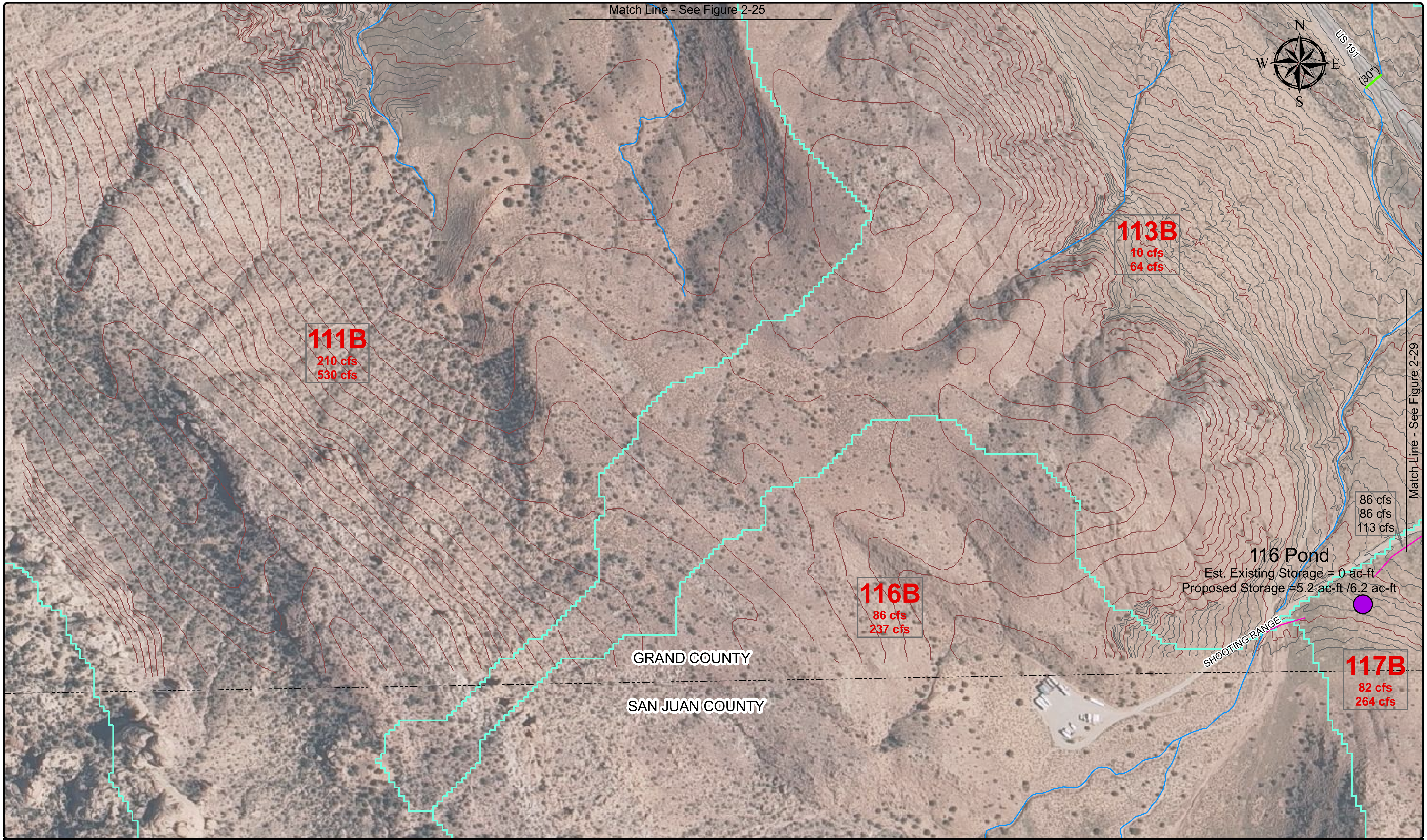
- Drainage Basin

FIGURE 2-27



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STORM DRAIN MASTER PLAN UPDATE

GRAPHIC SCALE
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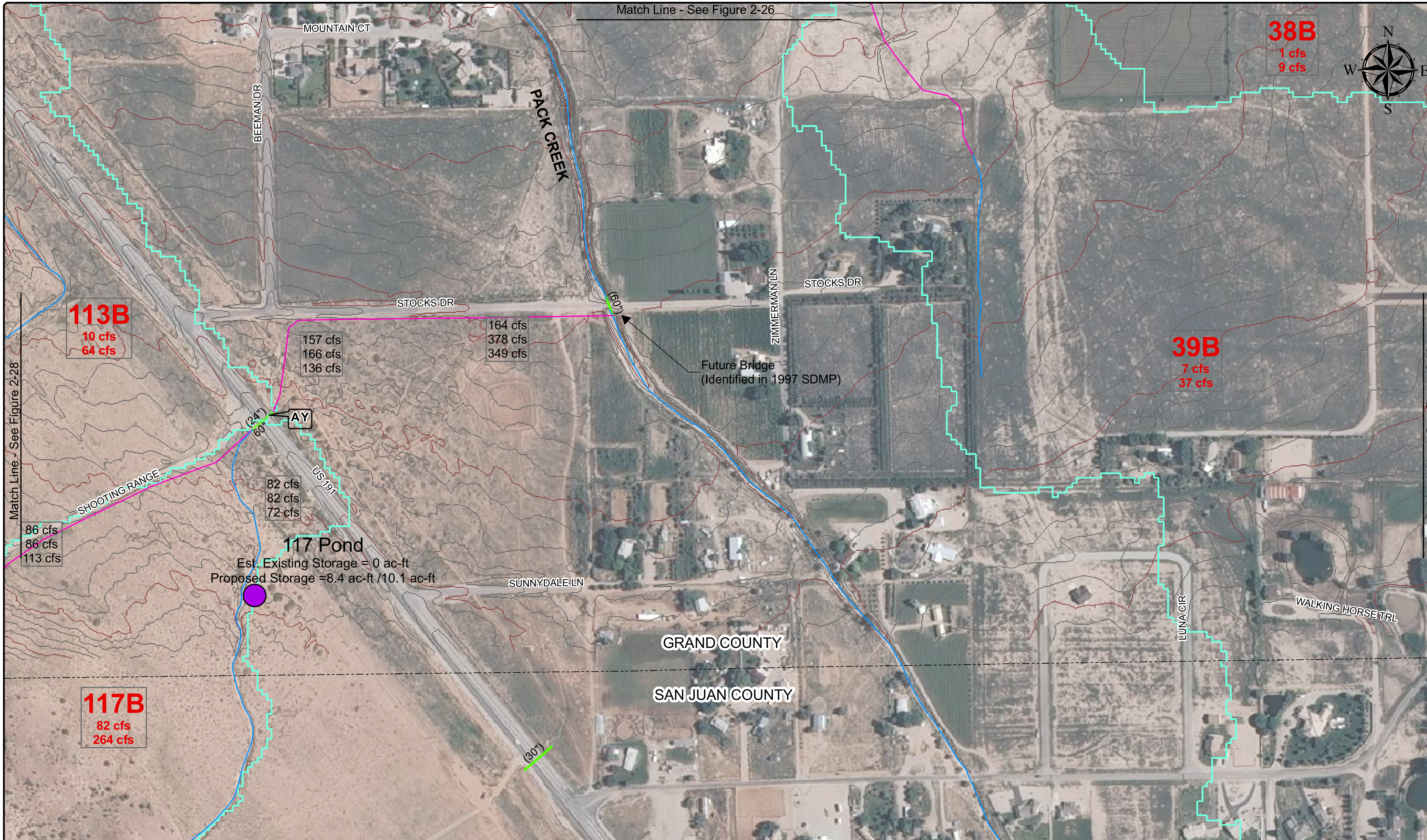
- Drainage Basin

FIGURE 2-28



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STORM DRAIN MASTER PLAN UPDATE

GRAPHIC SCALE

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FIGURE 2-29

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STORM DRAIN MASTER PLAN UPDATE

GRAPHIC SCALE

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LEGEND

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FIGURE 2-30

3 MANAGEMENT SYSTEM NEEDS

The storm water management system is designed to collect and convey all storm water to a safe point of release while protecting the safety of the public, and public and private property. For Spanish Valley, this system consists of a series of streets, ditches, storm drains and streams that flow into Pack Creek and Mill Creek, which in turn release into the Colorado River. The existing system was installed based on observed flows without much planning as to what could occur in the future. Because of this, there is a need to improve the system in order to meet the design criteria and design storm outlined earlier. The system needs have been determined from hydrologic calculations as explained in the previous chapter. This chapter discusses the capacity of existing facilities, the areas of needed improvement, the alternative solutions to meet these needs, and the recommended alternative.

3.1 EXISTING CAPACITY VS. MODEL FLOWS

3.1.1 PIPES AND CULVERTS

Figures 2-2 through 2-30 show the existing size of different components of the Spanish Valley drainage system. The existing flows were compared to the existing capacity of the drainage system. The actual conveyance capacity of culverts and trunk lines cannot be analyzed without field survey and inspection to determine the actual pipe diameter, pipe material, slope, entrance types, upstream and downstream channel geometry, and allowable headwater. This was not part of the scope of this Storm Drain Master Plan Update. Therefore, data from the previous Master Plan along with minimal information obtained from a single site visit and discussions with county staff were used to analyze culvert and storm drain capacity.

All culverts and detention basin outlet pipes were analyzed and sized based on the assumption that they are corrugated metal pipes (CMP) installed at a minimum slope of 1.0%, unless there was available information which dictated using different parameters. The allowable headwater on culverts was assumed to be 1.5 times the culvert diameter. For modeling purposes, it is also assumed that all culverts have a headwall or end section. It was also assumed that downstream channels have sufficient capacity so that they would not have any affects on inlet or outlet control. These parameters were used to determine the capacity of different culvert sizes using the Federal Highways Administration's HY-8 version 7.0 software program. Table 3-1 gives the maximum flow capacity per culvert diameter for both corrugated and smooth-lined pipes (SLP). Proposed culvert sizes were determined using Table 3-1.

Full flow capacities for corrugated and smooth-lined pipes, assuming a slope of 1.0%, were calculated based on Manning's Equation and are shown in Table 3-2. Smooth-lined pipes include concrete and smooth-lined HDPE. Manning's n values used for corrugated and smooth-lined pipes were 0.024 and 0.013, respectively. Full flow capacity was assumed when sizing trunk lines and longer pipe sections that would require manholes.

Prior to implementing any proposed improvements, all culverts and storm drain systems should be analyzed and designed further based on actual field survey and inspection data.

Table 3-1: Maximum Flow per Culvert Diameter @ Slope = 1.0%

Culvert Diameter (inches)	Maximum Flow (cfs) – Corrugated	Maximum Flow (cfs) – Smooth-lined (SLP)
18	7.3	10.0
24	16.1	20.4
30	29.6	35.7
36	48.5	56.3
42	73.7	82.7
48	105.4	115.5
54	144.5	155.1
60	191.4	201.8
66	246.3	256.1
72	309.8	318.3
84	464.6	468.0

Table 3-2: Full Flow Capacity per Pipe Diameter @ Slope = 1.0%

Culvert Diameter (inches)	Maximum Flow (cfs) – Corrugated	Maximum Flow (cfs) – Smooth-lined (SLP)
18	5.7	10.5
24	12.3	22.6
30	22.2	41.0
36	36.1	66.7
42	54.5	100.6
48	77.8	143.6
54	106.5	196.6
60	141.1	260.4
66	181.9	335.8
72	229.4	423.5
84	346.0	638.8

3.1.2 Storage Facilities

Figures 2-2 through 2-30 show the estimated existing storage capacity of existing regional storage basins throughout the Spanish Valley. The existing flows and the existing capacity of the storage facilities were compared with estimated required storage volumes in order to determine deficiencies. Many of the regional storage basins throughout the Spanish Valley have been constructed recently. Construction plans are available for many of these basins. However, it has been noted from field visits that many of these basins were not constructed as per plan. The actual capacity of storage basins cannot be analyzed without field survey and inspection. Since this was not part of the scope of this Storm Drain Master Plan Update, existing storage capacities were estimated based on available design plans, aerial images, available photos, and the 2 ft contour data used in the 1997 Storm Drain Master Plan model.

The needed and required storage volumes were estimated as outlined in section 2.1.4 Storage Basins Modeling. For some storage basins, the needed storage volume was decrease if it was noticed during the modeling process that the estimated storage volume was significantly more than what was needed for the allowable 10-yr historic release rate. Again, it should be noted that all storage basin volumes, including existing, needed and required, are *estimated* only. Determining the required storage volume is an iterative process. Prior to implementing any proposed improvements, existing storage facilities should be analyzed and proposed improvements designed based on actual field survey, inspection, and site specific data.

Locations of proposed regional storage facilities shown on the maps are approximate only. There is flexibility in the actual location of most storage facilities. Some storage facilities can also be broken up into multiple smaller facilities. Actual locations must be determined based on subsequent, more detail, studies and design and based on available property and right-of-way. Storage facilities should also be located based on the fewest impacts to existing property and where the fewest land acquisitions are needed. Flows can also be rerouted to locations where storage facilities are more feasible. However, storage facilities cannot be moved too far upstream or downstream of proposed locations without affecting their functionality as modeled in this Storm Drain Master Plan Update.

3.1.3 CHANNELS

In order to analyze the capacity of existing channels, parameters such as slope, geometry, lining material, and condition are needed. These parameters are available only through extensive field survey and inspection, which were not part of the scope of this Storm Drain Master Plan Update. Therefore, channels were not evaluated in this study. Previously proposed channel improvements from the 1997 Master Plan are carried into this Master Plan Update, unless they were verified to have since been installed. Locations of proposed channel diversions upstream and downstream of proposed storage basins have also been included. Upstream and downstream channels should be analyzed and improved as necessary with other proposed improvements when they are implemented. Other channels with noticed flooding problems should also be analyzed and improved with the needed modifications.

3.2 SYSTEM DEFICIENCIES

There are numerous components of the storm drainage system that are undersized and several developed areas without an existing drainage system. Conveyance system deficiencies and their proposed future improvements are listed in Table 3-3. Storage basin deficiencies and proposed improvements are listed in Table 3-4. The identifications (ID) given in Table 3-3 correspond to the pipe and drainage network identification labels on Figures 2-2 through 2-30. In the descriptions, items such as “7B” correspond to the drainage basin labels shown on Figures 2-2 through 2-30. In Table 3-3, all proposed storm drain and culvert improvements assumed corrugated metal pipe at a 1.0% slope, except the following:

- Q – Culvert crossing Heaven Avenue near Spanish Valley Drive: 6’x10’ Concrete Box Culvert as proposed in previous Master Plan (1997)

- S – Culvert crossing Chapman Lane near Spanish Valley Drive: 6'x10' Concrete Box Culvert as proposed in previous Master Plan (1997)
- Z – Mill Creek Drive trunk line: assumed 36" Smooth-lined pipe at slope = 1.2%
- AT – Rim Village to Pack Creek trunk line along Spanish Valley Drive: assumed 72" smooth-line pipe at slope = 1.4%
- AW – Trunk line between 113 Pond and Pack Creek, crossing Spanish Valley Drive near Beeman Drive: assumed 30" smooth-lined pipe at slope = 0.3%

Table 3-3: Conveyance System Deficiencies and Proposed Improvements

ID	Description	Existing Size (in)	Proposed Size (in)	Design Flow (cfs)
A	Lulu Ln to Arbor Dr storm drain	-	36	34
B	Storm Drain between Arbor Dr and Pack Creek	24	48	65
C	Proposed Culverts crossing Murphy Ln southeast of Arbor Dr (7B outlet)	18	42	59
D	Culvert crossing West Kayenta Dr near North Kayenta Dr	36	60	159
E	Storm Drain between Marshall Ln & detention basin on Munsey Dr	42	72	183
F	Proposed 42" Storm Drain crossing Murphy Ln to Pack Creek (11B outlet)	24	42	49
G	Storm Drain crossing Murphy Ln to Pack Creek (Basin 12B outlet)	36	48	56
H	Proposed 54" Culvert along Mitch Williams Dr, upstream of 15b Pond	24	54	109
I	Culvert crossing West Highland Dr	18	42	64
J	72" Storm Drain which crosses Murphy Ln just east of Solar Terrace	48	72	191
K	2 Culverts at intersection of Cedar Hills Dr & Murphy Ln	36	42	54
L	Culvert crossing Canyonlands North Circle	36	42	56
M	Culvert crossing Juniper Dr (in Basin 19B)	36	42	56
N	Culvert crossing Desert Hills Dr near Murphy Ln	18	24	13
O	Westwater Dr trunk line	18	24	12
P	Proposed 48" Culvert crossing East Bench Rd south of the Golf Course (26B outlet)	36	48	96
Q	Proposed 6'x10' Box Culvert crossing Heaven Ave near Spanish Valley Dr	60	6'x10' Box	640
R	Culvert crossing Spanish Valley Dr near Heaven Ave		36	37
S	Proposed 6'x10' Box Culvert crossing Chapman Ln near Spanish Valley Dr	60	6'x10' Box	640
T	Jackson St/400 E trunk line	54	66	158

ID	Description	Existing Size (in)	Proposed Size (in)	Design Flow (cfs)
U	Boulder Ave to Pack Creek trunk line	-	72	210
V	Bowling Alley Ln to Pack Creek trunk line	24	42	50
W	Proposed 42" Culvert crossing HW 191 just west of Wagner Ave	30	42	63
Y	Proposed 48" Culvert crossing Wagner Ave near Pack Creek	36	48	77
Z	Mill Creek Dr trunk line	-	36" SLP	70
AA	Trunk line between Spanish Valley Dr and Pack Creek near Hunt Creek Dr	24	30	20
AB	Culvert crossing HW 191 west of Plateau Dr	36	42	52
AC	Culvert crossing Plateau Dr near Spanish Valley Dr	24	30	19
AD	Culvert crossing Spanish Valley Dr near Plateau Dr	24	30	19
AE	Culvert crossing Spanish Valley Dr near Plateau Circle	-	36	35
AF	Culvert crossing HW 191 near Resource Blvd	18	24	15
AG	Proposed 30" Culvert crossing Spanish Valley Dr west of Vista Grande Dr	18	30	18
AH	Culvert crossing HW 191 south of Arroyo Rd	24	30	18
AI	3 Culverts along HW 191 near Hance Rd	-	36	
AJ	Culvert crossing Roberts Dr southeast of Hance Rd	24	36	44
AK	Culvert crossing San Jose Rd at Spanish Valley Dr	24	42	50
AL	Culvert crossing Spanish Valley Dr near San Jose Rd	24	42	50
AM	42" Storm Drain east of Buena Vista Dr	-	42	50
AN	Proposed 48" Culvert crossing Spanish Valley Dr at Spanish Trail Rd	30	48	81
AO	Proposed 48" Culvert crossing HW 191 north of Hance Rd	36	48	75
AP	Culvert crossing Red Cliff Rd	30	36	37
AQ	Trunk line from Spanish Valley Dr to Pack Creek (Basin 102B outlet)	-	42	42
AR	Culvert crossing HW 191 near Rodeo Grounds Rd (103B outlet)	18	36	37
AS	Culvert at north end of Rodeo Grounds	-	36	33
AT	Rim Village to Pack Creek trunk line along Spanish Valley Dr	-	72" SLP	445
AU	Culvert crossing HW 191 south of Rodeo Grounds Rd	24	30	23
AV	Proposed 84" Culvert crossing HW 191 upstream of Rim Village	30	84	384
AW	Trunk line between 113 Pond & Pack Creek, crossing Spanish Valley Dr & Beeman Dr	-	30" SLP	10
AX	Culvert crossing HW 191 north of Stocks Dr (within Basin 113B)	24	30	23
AY	Culvert crossing HW 191 south of Stocks Dr	24	60	166

Table 3-4: Storage Basin Deficiencies and Proposed Improvements

Pond ID	Detention Basin Location/Description	Design Inflow (cfs)	Design Release Rate (cfs)	Storage To Spillway Crest (ac-ft): Estimated Existing Storage Capacity	Storage To Spillway Crest (ac-ft): Needed Storage	Storage To Spillway Crest (ac-ft): Required Storage w/ 20% Silting Factor	Comments
7	Murphy Lane & Arbor Drive (Parriott's Pond)	79	31	1	1.5	1.8	Modify Existing
8	Kayenta Drive (Basin 8 Outflow)	234	94	-	5.3	6.3	New Pond
10	Muncey Drive & Murphy Lane	198	131	1.3	3.0	3.6	Modify Existing
11	Murphy Lane (Basin 11 Outflow)	65	25	0	1.3	1.5	Existing is silted in
12	Murphy Lane (Basin 12 Outflow)	77	30	-	1.5	1.8	New Pond
13	Upper West #1 (Basin 13 Outflow)	122	51	1.3	2.5	3.0	Modify Existing
14	Upper East (Basin 14 Outflow)	133	54	2.4	3.4	4.0	Modify Existing
15a	Upper West #2 (Basin 15a Outflow)	60	57	0.2	0.9	1.1	Modify Existing
15b	Central Basin (Basin 15b Outflow)	132	110	0.7	2.7	3.2	Modify per original design
18	Junction of Basin 18	239	152	0.1	7.7	9.3	Modify Existing
19	Basin 19 Outflow	109	26	-	4.3	5.1	New Pond
21	Basin 21 Outflow	42	5	-	2.3	2.7	New Pond
24	Westwater Drive Pond (Moab City)	57	16	?	1.5	1.8	Verify Existing Capacity
27	Golf Course Pond	84	77	?	0.7	0.9	Verify Existing Capacity
29	Upper Golf Course (Basin 29 Outflow)	193	67	-	8.4	10.1	New Pond
30	Basin 30 Outflow	98	20	-	16.9	20.3	New Pond
32	Basin 32 Outflow	42	15	-	1.0	1.2	New Pond
34	Basin 34 Outflow	124	50	-	2.5	3.0	New Pond
37	Basin 37 Outflow	62	21	-	2.4	2.8	New Pond
40	Basin 40 Outflow	146	54	-	4.5	5.5	New Pond
50	Jackson Street Pond (Basin 50 & 51 Outflow)	136	65	-	2.0	2.3	New Pond
54	Boulder Ave Pond (Basin 54 & 55)	250	114	1.6	3.8	4.6	2.5 ac-ft designed capacity

Pond ID	Detention Basin Location/Description	Design Inflow (cfs)	Design Release Rate (cfs)	Storage To Spillway Crest (ac-ft)			Comments
				Estimated Existing Storage Capacity	Needed Storage	Required Storage w/ 20% Silting Factor	
58	Basin 58 Outflow	20	2	-	0.9	1.1	New Pond
66	Basin 66 Outflow (Sage Trunk line Inflow)	105	20	-	4.8	5.8	New Pond
70	Mill Creek Drive Pond (Basin 70 Outflow)	46	5	3.6	5.2	6.2	Modify Existing
73	Basin 73 Outflow	13	1	-	1.7	2.1	New Pond
75	Basin 75 Outflow	272	52	-	16.4	19.7	New Pond
84	Junction 84 Outflow	175	27	-	8.1	9.7	New Pond
90	Junction 90 Outflow	168	33	-	10.6	12.7	New Pond
98	Basin 98 Outflow	98	18	-	4.3	5.1	New Pond
99	Basin 99 Outflow	173	37	-	7.2	8.6	New Pond
103	Basin 103 Outflow	62	24	-	1.3	1.6	New Pond
110	Basin 110 Outflow	23	2	-	2.0	2.4	New Pond
111	Basin 111 Outflow	530	201	9	11.6	13.9	Modify Existing
113	Basin 113 Outflow	64	10	-	5.2	6.3	New Pond
116	Basin 116 Outflow	237	86	-	5.2	6.2	New Pond
117	Basin 117 Outflow	264	82	-	8.4	10.1	New Pond

3.3 ALTERNATIVE SOLUTIONS

There are a number of ways to manage storm water. These include:

- Do Nothing – Although the do nothing alternative should always be considered, this alternative could be very costly in the long run due to flooding and damage that could occur.

- Purchase Flood Ways - This alternative consists of purchasing all of the land and structures in a flood plain large enough to contain the predicted flow from a 100-year storm. This would eliminate the problem of flooding private property. The number of existing homes and proposed homes in the projected flood plains make this alternative very costly. Besides the cost of the land, would be the cost of at least some improvements to assure that flood waters were not diverted from the flood way at road and canal crossings. It is estimated that this alternative would cost several million dollars because of the homes in the flood plain that would need to be purchased. However, there are some sections of the drainage corridor where this concept might work very well.

- Full Conveyance - This alternative consists of collecting all of the runoff and conveying it to a safe point of release (Colorado River). This system requires that all of the components have a capacity at least equal to the peak developed flow. The conveyance system could be constructed as a piped system, a lined channel, and/or a natural drainage way. The piped system would require a small right-of-way and be out of sight and almost maintenance free, but it would be the most costly. The lined channel could be costly and unattractive but it would handle large flows in a small right-of-way. The natural drainage way could be environmentally friendly, aesthetically pleasing, and usually has relatively low costs involved; however, it would have to be protected and maintained and could require a larger right-of -way.

- Detention with Historic Release and Conveyance - This consists of requiring new developments to manage the additional storm water runoff generated by them to an historic release rate. This alternative could be environmentally friendly and aesthetically pleasing. It also incorporates sound management practices. There are three different ways to accomplish the detention requirements. These include local detention, regional detention and in line detention. The local detention is development specific and allows individual developments to meet this requirement without collaboration with others. The regional detention would serve the drainage from several developments and existing washes. This would create larger open/green spaces, but would require collaboration between developers and the County. In line detention would require a large area with the main drainage corridor flowing through the detention basin. This would create large open spaces, but would require large amounts of land in the vicinity of the drainage corridors and larger collection facilities to handle the peak flows within the drainage corridors. The most economical system would probably be one that combines all three types of detention.

3.4 DRAINAGE IMPROVEMENTS RECOMMENDATION CRITERIA

The selection of a design alternative is based on several criteria to make sure it will function to the fullest. The criteria used in this selection are as follows:

- Level of Service and Design Criteria - The selected alternative must meet established levels of service and the design criteria outlined in the *Grand County Design Criteria for Drainage Studies Within Spanish Valley.*
- Philosophy - The alternative must include proper storm water management. This is to make sure that problems are solved and not just postponed to a later time in the future.
- Cost - The recommended alternative must be economical in design and construction costs while functioning properly.
- Feasibility - The alternative must be feasible to design, construct and maintain. It must fall within the realm of common construction practices.
- FEMA - The alternative must be acceptable by FEMA standards.
- EPA - Storm water quality within the Spanish Valley will be regulated by the EPA in the near future, if it is not already. Considering EPA regulations now will reduce the cost of compliance in the future.
- Environmental Enhancement - The construction of a storm water management facility provides a great opportunity to add to the environmental conditions of the valley.
- Recreation Possibilities - The ability to combine storm water management and recreation projects, such as using parks for recreation and storm water detention facilities, could reduce the cost of design, construction and land acquisition.
- Aesthetics - A visually pleasing system could add to the beauty of the valley and be politically acceptable.

3.5 Recommended Alternative

The recommended alternative for managing the storm water generated in the Spanish Valley is detention with an historic release rate. Conveyance systems will also be constructed below detention facilities to manage the design release rate and emergency spillway flows. This alternative is recommended because it is the only alternative discussed that will fit the outlined criteria effectively. All proposed drainage improvements shown in Figures 2-2 through Figure 2-30 conform to this alternative. Regional detention basins with capacity for existing flow rates are proposed in this report and local detention facilities will be required for all future developments to detain post-developed flows. The method of detention is left to the developers and county planners who may want to see regional basins which would provide larger areas to be used for other proposes, like parks, and probably require less maintenance. Through coordination between developers and the County, regional detention basins could be upsized to include post-developed flows. The method of conveyance will be the use of the natural drainage ways where possible, as well as storm drain systems and culverts where needed.

The do nothing alternative could be too costly and is not acceptable to the County. This would create some chaos as developers would be left to manage their storm water as they please.

Re-establishment of the Flood Ways is by far the most natural solution. However, in most cases it is unreasonable and would also be far more costly than improved storm water management systems. However, there may be sections of the drainage corridor where this alternative would work very well and should be used in conjunction with the recommended alternative as conveyance systems.

The full conveyance alternative would not address water quality issues, nor would it conform to the criteria of this report or the Grand County drainage design standards. This alternative would be more costly than other alternatives if piped or put in a lined channel.

The detention alternative would require developers to manage increased storm water, and help clean the water before it is released into the conveyance system. This alternative would be aesthetically pleasing, have good recreational possibilities, be more acceptable to governing agencies, be environmentally friendly, reduce the flood plain, be feasible and economical, meet the level of service and design criteria outlined, and follows the current philosophies of best management practices.

An option to improving all of the outfall channels would be to preserve and maintain some of the existing flood ways (drainage ways) as outlined above in the Flood Way Alternative. These would not necessarily need to be purchased if an easement could be obtained contingent to development approval. Some of these flood ways may need to be expanded in order to handle the increased storm flows. The cost of expanding these drainages should be investigated along with other improvement options.

3.6 Proposed Improvements Review

All proposed improvements outlined in this report are presented for planning and guidance only. This report identifies deficiencies and gives recommended improvements based on a uniform and large scale analysis approach. There may be other possible solutions for drainage deficiencies that still meet the design criteria, level of service, and recommended improvement alternative outlined in this report. Therefore, all proposed improvements should be reviewed prior to implementation in order to design site specific improvements that are the most economical, realistic, and feasible for each identified drainage system deficiency.

A good example of an area where other possible solutions to the proposed improvements outlined should be investigated is the existing 9 ac-ft detention basin located at the outlet of drainage Basin 111, upstream of Rim Village. The proposed improvements include upsizing the detention basin by 5 ac-ft to a storage volume of 14 ac-ft to allow for the 10-yr historic release rate of 200 cfs. It is estimated that the existing 30-inch outlet from the detention basin only has an outlet capacity of 70 cfs with the allowable headwater at the existing spillway crest. It is estimated that a 48-inch outlet pipe would be required for a release rate of 200 cfs with the existing dam height. Furthermore, the proposed improvements outlined in this report would require the installation of a 72-inch smooth-lined trunk line downstream of Rim Village. The existing channel and culvert system through Rim Village may also need to be upsized in order to have adequate capacity. It may be more economical and realistic to increase the storage volume upstream of Rim Village even more than the proposed 5 ac-ft, either by adding additional detention basins or by additional increase to the existing detention facility. This may allow for the existing outlet pipe to be used and for a smaller trunk line downstream of Rim Village.

3.7 Collection and Minor Storm Drainage Facilities

There are some localized drainage problems that the master planning process could not accurately identify since this study focused on evaluating major storm drain facilities. County personnel will have to rely on observations of County Staff and residents to determine where any serious drainage system problems exist in areas that are not served by major storm drainage improvements. This includes problems related to the lack of road side drainage features.

For logical reasons, major collection facilities were not proposed if street and roadside drainage facilities manage the design flows. This approach relies on the existence of curb and gutter or road side ditches. Localized problems in some areas occur due to the lack of curb and gutter or other road side conveyance facilities. The need for collection facilities will depend on the sequence of development and other local factors that could not be fully determined. Therefore, County personnel will need to rely on continued observation in the determination of, the location of, and need for collection facilities.

4 PRIORITIZED DRAINAGE SYSTEM IMPROVEMENTS

4.1 PRIORITIZED IMPROVEMENTS

One of the purposes of this study was to develop prioritization and cost estimates of all recommended drainage improvements. All recommended drainage improvements throughout the Spanish Valley are prioritized based on a generated formula.

Subjective damage factors were developed for each of the recommended drainage improvements. The subjective damage factors were developed to help estimate the severity of problem areas in the valley and to help prioritize the valley-wide list of recommended improvements. These factors were based on assumed conditions from an evaluation of the performance of existing drainage facilities assuming that they were receiving runoff from the design flows outlined previously and shown in Figures 2-2 through 2-30. Storage basins were assigned values for damage factors based on design flows, without consideration of proposed drainage improvements downstream. This was done since downstream improvements are based on flows from the proposed storage basins. Conveyance systems were assigned values for damage factors assuming storage basins and all other improvements are in place upstream.

Potential damage factors and seven variables were evaluated for each improvement. The variables include damage, flooding, storm probability, and a factor for input from the County Council and staff selected by the County Engineer. Input from the County helps to prioritize improvements according to the County's preference – based on need, noticed problems, funding, or any other factor. A County Input value for each improvement has been included, assigned by the County based on input from the community at a Public Open House and decisions made at County Council Meetings. Factors assigned for potential flooding and damage are based on existing (2009) conditions. The given variables developed for the formula are as follows:

D = Damage estimate in terms of cost (0-4, with 4 being high and 0 being minimal or none)

C = Commercial Building Inundation (0-4, with 4 being high and 0 being minimal or none)

R = Residential Building Inundation (0-4, with 4 being high and 0 being minimal or none)

S = Street Inundation (0-none, 1-inundation of local or minor collectors, 2-inundation of arterial or major collector)

I = County Input (0-4, 4 being the highest prioritization)

10yr Storm = Current Component Will Manage the 10-year Storm (1-yes, 3-no)

100yr Storm = Current Component Will Manage the 100-year Storm (0-yes, 2-no)

The prioritization formula used is: Total = (D+C+R+S+I) x (10yr Storm + 100yr Storm)

This formula adds the possibilities of flooding, probable damage and the County Input together and multiplies them by the sum of the storm factors. Since the storm factors were considered more significant than the other factors, they are multiplied by the sum of the other factors. Also, the 10-yr storm was weighted heavier than the 100-yr storm, since it occurs more frequently and identifies more immediate risks of damage and inundation. The higher the total is, means a greater priority. It was felt that these factors and formula would best prioritize the needed improvements. Once a total priority value for each drainage improvement was obtained, the priorities were numerically sorted from greatest to lowest value. The priorities were then assigned a qualitative value from A through F (a value of A is the highest priority). The qualitative values were broken up by providing a somewhat even distribution of the qualitative values and based on noticeable breaks in the total priority scores, reflecting how the scores were generally lumped together.

A prioritized list of recommended storm drainage system improvements was then developed using the prioritization formula discussed above. Table 4-1 summarizes the conveyance system improvements prioritization, while Table 4-2 summarizes the storage basin improvements prioritization. It should be noted that this prioritization is not hard and fast, but should be used for planning purposes only. The County still has the authority to implement the drainage improvements according to whatever order and schedule they feel is best. The County may re-prioritize the drainage improvements according to factors such as budget, available funding, coincidence with other projects, changes in needs or land development, or for any other reason or factor that they deem applicable.

4.2 Other Factors Affecting Prioritization

The prioritization process developed is a good means of ranking the improvements. There are, however, other factors affecting when and the order in which the recommended improvements should and will be build. Note that it is not that important whether a component is ranked A vs. B or C vs. D on the overall listing. The method for determining the prioritization factors was not exact enough to determine such a small differential in the ranking process. It is important, however, that projects that rank in priority A or B be built before those that were ranked lower. Improvements ranked in the lower third of the rankings should not be built before improvements in the upper third unless the other factors discussed below apply.

4.2.1 Road Construction

The County Road Department (CRD) has responsibility for road maintenance and construction within the valley. There are large cost savings to the County by constructing drainage improvements during road construction and re-construction. As the CRD constructs roads or improves roads in the future, the County should replace or build drainage improvements as needed. This may result in some improvements being built before others that are ranked higher on the list.

4.2.2 CONSTRUCTION SEQUENCING

As with all systems, there are certain components that need to be built before others. As an example, the lower sections of an enlarged conduit should be built before the upper sections. Otherwise, the larger flow capacity in the upstream conduit could not be carried in the smaller downstream section. Other examples include upstream detention basins which are critical to the reduction of flows in conveyance systems downstream. Upstream detention basins should be built prior to downstream improvements or should be sequenced together. The county staff should consider construction sequencing when implementing the recommended improvements.

4.2.3 FUTURE DEVELOPMENT OR LACK THEREOF

The analysis of the storm water management system was made based on existing conditions within the valley. Improvements in areas with less existing development were ranked lower than those improvements needed in existing residential and commercial areas. Lower ranked improvements may rise to a higher priority as new development occurs. Some drainage improvements, such as recommended storage basins on the southwest end of the valley may not need to be implemented until development in those areas occurs or additional flooding problems begin to appear. The county staff should monitor development in all areas of the valley to determine its affect on the storm water management system and the implementation of the recommended improvements.

4.2.4 FUTURE NPDES REQUIREMENTS

Future requirements of the EPA's National Pollution Discharge Elimination System (NPDES) program for storm water quality could affect the order that recommended improvements are built, or could result in the development of new improvements, to respond to changing NPDES requirements. The affect of this program on recommended improvements and the order of their construction are not known at this time.

Table 4-1: Conveyance System Improvements Prioritization

ID	Description	Prioritization: Total = (D+C+R+S+I) x (10yr + 100yr)								
		Damage, D (0-4)	Commercial Inundation, C (0-4)	Residential Inundation, R (0-4)	Street Inundation, S (0-2)	County Input, I (0-4)	10-yr Storm (1,3)	100-yr Storm (0,2)	Total	Priority
AT	Rim Village to Pack Creek trunk line along Spanish Valley Dr	4	0	4	2	4	3	2	70	**A**
U	Boulder Ave to Pack Creek trunk line	4	4	4	2	0	3	2	70	**A**
Z	Mill Creek Dr trunk line, including upstream channel improvements	4	4	4	2	0	3	2	70	**A**
V	Bowling Alley Ln to Pack Creek trunk line, including upstream channel improvements	3	3	4	1	0	3	2	55	**A**
W	Proposed 42" Culvert crossing HW 191 just west of Wagner Ave	3	2	4	2	0	3	2	55	**A**
AV	Proposed 84" Culvert crossing HW 191 upstream of Rim Village	3	0	1	2	4	3	2	50	**A**
AN	Proposed 48" Culvert crossing Spanish Valley Dr at Spanish Trail Rd	2	0	2	2	3	3	2	45	**B**
Y	Proposed 48" Culvert crossing Wagner Ave near Pack Creek	4	0	4	1	0	3	2	45	**B**
T	Jackson St/400 E trunk line, including channel improvements	4	4	4	2	0	1	2	42	**B**
A	Lulu Ln to Arbor Dr storm drain	4	0	3	1	0	3	2	40	**B**
C	Proposed Culverts crossing Murphy Ln southeast of Arbor Dr (7B outlet)	2	0	2	2	0	3	2	30	**C**
F	Proposed 42" Storm Drain crossing Murphy Ln to Pack Creek (11B outlet)	2	0	2	2	0	3	2	30	**C**
O	Westwater Dr trunk line	2	0	3	1	0	3	2	30	**C**
P	Proposed 48" Culvert crossing East Bench Rd south of the Golf Course (26B outlet)	3	0	2	1	0	3	2	30	**C**

ID	Description	Prioritization: Total = (D+C+R+S+I) x (10yr + 100yr)								
		Damage, D (0-4)	Commercial Inundation, C (0-4)	Residential Inundation, R (0-4)	Street Inundation, S (0-2)	County Input, I (0-4)	10-yr Storm (1,3)	100-yr Storm (0,2)	Total	Priority
E	Storm Drain between Marshall Ln & detention basin on Munsey Dr	3	0	3	2	1	1	2	27	**C**
AP	Culvert crossing Red Cliff Rd	1	2	1	1	0	3	2	25	**C**
AO	Proposed 48" Culvert crossing HW 191 north of Hance Rd	2	2	2	2	0	1	2	24	**C**
AW	Trunk line between 113 Pond & Pack Creek, crossing Spanish Valley Dr & Beeman Dr	2	0	2	2	2	1	2	24	**C**
B	Strom Drain between Arbor Dr and Pack Creek	4	0	3	1	0	1	2	24	**C**
J	72" Storm Drain which crosses Murphy Ln just east of Solar Terrace, including channel improvements	3	0	3	2	0	1	2	24	**C**
AU	Culvert crossing HW 191 south of Rodeo Grounds Rd	1	1	0	2	4	1	2	24	**C**
AS	Trunk line at north end of Rodeo Grounds, including upstream channel improvements	2	0	3	1	2	1	2	24	**C**
AM	42" Storm Drain east of Buena Vista Dr	3	0	3	1	0	1	2	21	**D**
AQ	Trunk line from Spanish Valley Dr to Pack Creek (Basin 102B outlet), including upstream channel improvements	2	0	2	2	1	1	2	21	**D**
AB	Culvert crossing HW 191 west of Plateau Dr	1	1	0	2	0	3	2	20	**D**
AE	Culvert crossing Spanish Valley Dr near Plateau Circle, including channel improvements	1	0	1	2	0	3	2	20	**D**
AY	Culvert crossing HW 191 south of Stocks Dr, including downstream channel improvements	2	0	0	2	0	3	2	20	**D**

ID	Description	Prioritization: Total = (D+C+R+S+I) x (10yr + 100yr)							Total	Priority
		Damage, D (0-4)	Commercial Inundation, C (0-4)	Residential Inundation, R (0-4)	Street Inundation, S (0-2)	County Input, I (0-4)	10-yr Storm (1,3)	100-yr Storm (0,2)		
D	Culvert crossing West Kayenta Dr near North Kayenta Dr	1	0	2	1	0	3	2	20	**D**
I	Culvert crossing West Highland Dr	2	0	1	1	0	3	2	20	**D**
R	Culvert crossing Spanish Valley Dr near Heaven Ave, including channel improvements	1	0	1	2	0	3	2	20	**D**
AA	Trunk line between Spanish Valley Dr and Pack Creek near Hunt Creek Dr	1	1	2	2	0	1	2	18	**E**
AK	Culvert crossing San Jose Rd at Spanish Valley Dr, including channel improvements	2	0	2	2	0	1	2	18	**E**
AL	Culvert crossing Spanish Valley Dr near San Jose Rd	2	0	2	2	0	1	2	18	**E**
AX	Culvert crossing HW 191 north of Stocks Dr (within Basin 113B)	1	0	0	2	3	1	2	18	**E**
AI	3 Culverts along HW 191 near Hance Rd, including channel improvements	1	2	0	2	0	1	2	15	**E**
AR	Culvert crossing HW 191 near Rodeo Grounds Rd (103B outlet), including channel improvements	1	0	0	2	0	3	2	15	**E**
K	2 Culverts at intersection of Cedar Hills Dr & Murphy Ln, including upstream channel improvements	2	0	1	2	0	1	2	15	**E**
L	Culvert crossing Canyonlands North Circle	2	0	2	1	0	1	2	15	**E**
M	Culvert crossing Juniper Dr (in Basin 19B)	2	0	2	1	0	1	2	15	**E**
N	Culvert crossing Desert Hills Dr near Murphy Ln	1	0	1	1	0	3	2	15	**E**
Q	Proposed 6'x10' Box Culvert crossing Heaven Ave near Spanish Valley Dr	2	0	2	1	0	1	2	15	**E**

ID	Description	Prioritization: Total = (D+C+R+S+I) x (10yr + 100yr) Damage, D (0-4)	Commercial Inundation, C (0-4)	Residential Inundation, R (0-4)	Street Inundation, S (0-2)	County Input, I (0-4)	10-yr Storm (1,3)	100-yr Storm (0,2)	Total	Priority
S	Proposed 6'x10' Box Culvert crossing Chapman Ln near Spanish Valley Dr	2	0	2	1	0	1	2	15	**E**
AD	Culvert crossing Spanish Valley Dr near Plateau Dr, including channel improvements	1	0	1	2	0	1	2	12	**F**
AF	Culvert crossing HW 191 near Resource Blvd, including downstream channel improvements	1	1	0	2	0	1	2	12	**F**
G	Storm Drain crossing Murphy Ln to Pack Creek (Basin 12B outlet)	1	0	1	2	0	1	2	12	**F**
H	Proposed 54" Culvert along Mitch Williams Dr, upstream of 15b Pond	1	0	1	0	0	3	2	10	**F**
AC	Culvert crossing Plateau Dr near Spanish Valley Dr	1	0	1	1	0	1	2	9	**F**
AG	Proposed 30" Culvert crossing Spanish Valley Dr west of Vista Grande Dr	1	0	0	2	0	1	2	9	**F**
AH	Culvert crossing HW 191 south of Arroyo Rd	1	0	0	2	0	1	2	9	**F**
AJ	Culvert crossing Roberts Dr southeast of Hance Rd	1	0	1	1	0	1	2	9	**F**

Table 4-2: Storage Basin Improvements Prioritization

Pond ID	Detention Basin Location/Description	Prioritization: Total = (D+C+R+S+I) x (10yr + 100yr) Damage, D (0-4)	Commercial Inundation, C (0-4)	Residential Inundation, R (0-4)	Street Inundation, S (0-2)	County Input, I (0-4)	10-yr Storm (1,3)	100-yr Storm (0,2)	Total	Priority
98	Basin 98 Outflow	3	2	2	2	1	3	2	50	**A**
99	Basin 99 Outflow, including channel improvements	3	2	2	2	1	3	2	50	**A**
54	Boulder Ave Pond (Basin 54 & 55)	4	4	4	2	0	1	2	42	**A**
70	Mill Creek Drive Pond (Basin 70 Outflow)	4	4	4	2	0	1	2	42	**A**
111	Basin 111 Outflow	4	0	4	2	4	1	2	42	**A**
116	Basin 116 Outflow, including channel improvements	2	0	2	2	2	3	2	40	**A**
50	Jackson Street Pond (Basin 50 & 51 Outflow)	4	4	3	2	0	1	2	39	**A**
113	Basin 113 Outflow, including upstream channel improvements	2	0	3	2	4	1	2	33	**B**
11	Murphy Lane (Basin 11 Outflow)	2	0	2	2	0	3	2	30	**B**
75	Basin 75 Outflow, including channel improvements	2	2	0	2	0	3	2	30	**B**
103	Basin 103 Outflow	2	0	2	2	0	3	2	30	**B**
117	Basin 117 Outflow	2	0	2	2	0	3	2	30	**B**
8	Kayenta Drive (Basin 8 Outflow)	3	0	3	2	1	1	2	27	**C**
10	Muncey Drive & Murphy Lane	3	0	3	2	1	1	2	27	**C**
13	Upper West #1 (Basin 13 Outflow)	3	0	4	2	0	1	2	27	**C**
14	Upper East (Basin 14 Outflow)	3	0	4	2	0	1	2	27	**C**
19	Basin 19 Outflow	3	0	3	2	1	1	2	27	**C**
84	Junction 84 Outflow	3	2	2	2	0	1	2	27	**C**
15b	Central Basin (Basin 15 Outflow)	3	0	4	2	0	1	2	27	**C**

Pond ID	Detention Basin Location/Description	Prioritization: Total = (D+C+R+S+I) x (10yr + 100yr) Damage, D (0-4)	Commercial Inundation, C (0-4)	Residential Inundation, R (0-4)	Street Inundation, S (0-2)	County Input, I (0-4)	10-yr Storm (1,3)	100-yr Storm (0,2)	Total	Priority
7	Murphy Lane & Arbor Drive (Parriott's Pond)	1	0	2	2	0	3	2	25	**D**
29	Upper Golf Course (Basin 29 Outflow)	2	0	2	1	0	3	2	25	**D**
21	Basin 21 Outflow	3	0	3	1	1	1	2	24	**D**
66	Basin 66 Outflow (Sage Trunk line Inflow)	3	1	3	1	0	1	2	24	**D**
73	Basin 73 Outflow, including channel improvements	3	0	3	2	0	1	2	24	**D**
110	Basin 110 Outflow	2	1	3	1	1	1	2	24	**D**
58	Basin 58 Outflow	2	3	0	2	0	1	2	21	**E**
15a	Upper West #2 (Basin 15a Outflow)	2	0	3	2	0	1	2	21	**E**
30	Basin 30 Outflow	2	0	2	1	0	1	2	15	**E**
12	Murphy Lane (Basin 12 Outflow)	1	0	1	2	0	1	2	12	**E**
27	Golf Course Pond, including channel improvements	1	0	2	1	0	1	2	12	**E**
18C	Junction of Basin 18 (18Pond)	1	0	2	1	0	1	2	12	**E**
32	Basin 32 Outflow	1	0	1	1	0	1	2	9	**F**
34	Basin 34 Outflow	1	0	1	1	0	1	2	9	**F**
37	Basin 37 Outflow	1	0	1	1	0	1	2	9	**F**
24	Westwater Drive Pond (Moab City)	0	0	1	1	0	1	2	6	**F**
40	Basin 40 Outflow	1	0	1	0	0	1	2	6	**F**
90	Junction 90 Outflow	1	0	1	0	0	1	2	6	**F**

4.3 Drainage System Improvements Cost Estimate

For purposes of determining funding needs for the construction of drainage improvements, cost estimates for these improvements are included in Table 4-3. The cost estimates include all the drainage improvements identified in sections 3 and 4. The identifications given in Table 4-3 refer to the conveyance systems ID labels and Pond ID labels on Figures 2-2 through 2-30 and also correspond to the ID's given in Table 3-3, Table 3-4, Table 4-1, and Table 4-2.

Table 4-3: Drainage Improvements Cost Estimate

ID / Pond ID	Item Description	Unit	Quantity	Unit Cost ($)	Total Cost ($)	Priority
A	Connect To Existing Sump	EA	1	$500	$500	B
	36" CMP	LF	450	$120	$54,000	
	Manhole	EA	1	$6,000	$6,000	
	Total Cost				$60,500	
B	Remove Existing Pipe	LF	230	$20	$4,600	C
	48" CMP	LF	230	$200	$46,000	
	Manhole	EA	1	$6,000	$6,000	
	48" End Section	EA	1	$2,500	$2,500	
	Total Cost				$59,100	
C	Remove Existing 18"	LF	105	$20	$2,100	C
	Remove Existing 24"	LF	160	$20	$3,200	
	42" CMP	LF	265	$160	$42,400	
	42" End Section	EA	4	$2,000	$8,000	
	Total Cost				$55,700	
D	Remove Existing 36"	LF	80	$30	$2,400	D
	60" CMP	LF	80	$240	$19,200	
	60" Headwall	LF	2	$8,000	$16,000	
	Total Cost				$37,600	
E	Remove Existing 42"	LF	540	$30	$16,200	C
	72" CMP	LF	540	$320	$172,800	
	Manhole	EA	3	$6,000	$18,000	
	72" Headwall	LF	2	$12,000	$24,000	
	Total Cost				$231,000	
F	Remove Existing 24"	LF	65	$20	$1,300	C
	42" CMP	LF	615	$160	$98,400	
	Manhole	EA	2	$6,000	$12,000	
	42" End Section	EA	2	$2,000	$4,000	
	Culvert/Pipe Easement (30"-48")	LF	347	$76	$26,372	
	Total Cost				$142,072	
G	Remove Existing 36"	LF	110	$30	$3,300	F

ID / Pond ID	Item Description	Unit	Quantity	Unit Cost ($)	Total Cost ($)	Priority
	48" CMP	LF	782	$200	$156,400	
	48" End Section	EA	2	$2,500	$5,000	
	Manhole	EA	1	$6,000	$6,000	
	Culvert/Pipe Easement (30"-48")	LF	782	$76	$59,432	
	Total Cost				$230,132	
H	Remove Existing 24”	LF	90	$20	$1,800	F
	54" CMP	LF	90	$220	$19,800	
	54" Headwall	EA	2	$6,000	$12,000	
	Total Cost				$33,600	
I	Remove Existing 18”	LF	75	$20	$1,500	D
	42" CMP	LF	75	$160	$12,000	
	42" End Section	EA	2	$2,000	$4,000	
	Total Cost				$17,500	
J	Remove Existing 48”	LF	680	$30	$20,400	C
	72" CMP	LF	680	$320	$217,600	
	Manhole	EA	1	$6,000	$6,000	
	72" Headwall	EA	2	$12,000	$24,000	
	Channel Improvements (large)	LF	180	$80	$14,400	
	Total Cost				$282,400	
K	Remove Existing 36”	LF	160	$30	$4,800	E
	42" CMP	LF	160	$160	$25,600	
	42" End Section	EA	4	$2,000	$8,000	
	Channel Improvements (small)	LF	2030	$45	$91,350	
	Total Cost				$129,750	
L	Remove Existing 36”	LF	100	$30	$3,000	E
	42" CMP	LF	100	$160	$16,000	
	42" End Section	EA	2	$2,000	$4,000	
	Total Cost				$23,000	
M	Remove Existing 36”	LF	80	$30	$2,400	E
	48" CMP	LF	80	$180	$14,400	
	48" End Section	EA	2	$2,500	$5,000	
	Total Cost				$21,800	
N	Remove Existing 18”	LF	80	$20	$1,600	E
	24" CMP	LF	80	$100	$8,000	
	24" End Section	EA	2	$900	$1,800	
	Total Cost				$11,400	
O	24" CMP	LF	1040	$100	$104,000	C
	Manhole	EA	3	$6,000	$18,000	
	24" End Section	EA	2	$900	$1,800	

ID / Pond ID	Item Description	Unit	Quantity	Unit Cost ($)	Total Cost ($)	Priority
	Total Cost				$123,800	
P	Remove Existing 36"	LF	80	$30	$2,400	C
	48" CMP	LF	80	$200	$16,000	
	48" End Section	EA	2	$2,500	$5,000	
	Total Cost				$23,400	
Q	Remove Existing 60"	LF	85	$40	$3,400	E
	6'X10' BOX	LF	85	$1,000	$85,000	
	Wing Walls	LS	2	$1,000	$2,000	
	Total Cost				$90,400	
R	36" CMP	LF	90	$120	$10,800	D
	36" End Section	EA	2	$1,600	$3,200	
	Channel Improvements (Medium)	LF	2410	$60	$144,600	
	Total Cost				$158,600	
S	Remove Existing 60"	LF	65	$40	$2,600	E
	6'x10' BOX	LF	65	$1000	$65,000	
	Wing Walls	LS	2	$1,000	$2,000	
	Total Cost				$69,600	
T	Remove Existing Pipe	LF	295	$20	$5,900	B
	66" CMP	LF	1085	$270	$292,950	
	Manhole	EA	3	$6,000	$18,000	
	66" Headwall	EA	2	$10,000	$20,000	
	Channel Improvements (Large)	LF	1890	$80	$151,200	
	Total Cost				$488,050	
U	Remove Existing 48"	LF	125	$30	$3,750	A
	72" CMP	LF	2230	$320	$713,600	
	Manhole	EA	6	$6,000	$36,000	
	72" Headwall	EA	2	$12,000	$24,000	
	Total Cost				$777,350	
V	Remove Existing 24"	LF	320	$20	$6,400	A
	42" CMP	LF	320	$160	$51,200	
	42" End Section	EA	2	$2,000	$4,000	
	Channel Improvements (Medium)	LF	615	$60	$36,900	
	Total Cost				$98,500	
W	Remove Existing 30"	LF	160	$20	$3,200	A
	42" CMP	LF	160	$160	$25,600	
	42" End Section	EA	2	$2,000	$4,000	
	Total Cost				$32,800	
Y	Remove Existing 36"	LF	70	$30	$2,100	B
	48" CMP	LF	70	$200	$14,000	

ID / Pond ID	Item Description	Unit	Quantity	Unit Cost ($)	Total Cost ($)	Priority
	48" End Section	EA	2	$2,500	$5,000	
	Total Cost				$21,100	
Z	36" Smooth Lined Pipe	LF	1880	$140	$263,200	A
	36" End Section	EA	2	$1,600	$3,200	
	Manhole	EA	6	$6,000	$36,000	
	Channel Improvements (medium)	LF	520	$60	$31,200	
	Total Cost				$333,600	
AA	Remove Existing 24"	LF	795	$20	$15,900	E
	30" CMP	LF	795	$110	$87,450	
	Manhole	EA	2	$6,000	$12,000	
	30" End Section	EA	2	$1,200	$2,400	
	Total Cost				$117,750	
AB	Remove Existing 36"	LF	160	$30	$4,800	D
	42" CMP	LF	160	$160	$25,600	
	42" End Section	EA	2	$2,000	$4,000	
	Total Cost				$34,400	
AC	Remove Existing 24"	LF	75	$20	$1,500	F
	30" CMP	LF	75	$110	$8,250	
	30" End Section	EA	2	$1,200	$2,400	
	Total Cost				$12,150	
AD	Remove Existing 24"	LF	90	$20	$1,800	F
	30" CMP	LF	90	$110	$9,900	
	30" End Section	EA	2	$1,200	$2,400	
	Channel Improvements (small)	LF	220	$45	$9,900	
	Total Cost				$24,000	
AE	Remove Existing 30"	LF	80	$20	$1,600	D
	36" CMP	LF	80	$120	$9,600	
	36" End Section	EA	2	$1,600	$3,200	
	Channel Improvements (small)	LF	605	$45	$27,225	
	Total Cost				$41,625	
AF	Remove Existing 18"	LF	110	$20	$2,200	F
	30" CMP	LF	110	$110	$12,100	
	30" End Section	EA	2	$1,200	$2,400	
	Channel Improvements (small)	LF	880	$45	$39,600	
	Total Cost				$56,300	
AG	Remove Existing 18"	LF	160	$20	$3,200	F
	30" CMP	LF	160	$110	$17,600	
	30" End Section	EA	2	$1,200	$2,400	
	Total Cost				$23,200	

ID / Pond ID	Item Description	Unit	Quantity	Unit Cost ($)	Total Cost ($)	Priority
AH	Remove Existing 24"	LF	120	$20	$2,400	F
	30" CMP	LF	120	$110	$13,200	
	30" End Section	EA	2	$1,200	$2,400	
	Total Cost				$18,000	
AI	42" CMP	LF	300	$160	$48,000	E
	42" End Section	EA	6	$2,000	$12,000	
	Channel Improvements (Small)	LF	245	$45	$11,025	
	Channel Improvements (medium)	LF	780	$60	$46,800	
	Total Cost				$117,825	
AJ	Remove Existing 24"	LF	90	$20	$1,800	F
	36" CMP	LF	90	$120	$10,800	
	36" End Section	EA	2	$1,600	$3,200	
	Total Cost				$15,800	
AK	42" CMP	LF	75	$160	$12,000	E
	42" End Section	EA	2	$2,000	$4,000	
	Channel Improvements (Medium)	LF	480	$60	$28,800	
	Total Cost				$44,800	
AL	Remove Existing 24"	LF	50	$20	$1,000	E
	42" CMP	LF	100	$160	$16,000	
	42" End Section	EA	2	$2,000	$4,000	
	Total Cost				$21,000	
AM	42" CMP	LF	943	$160	$150,880	D
	Manhole	EA	2	$6,000	$12,000	
	42" End Section	EA	2	$2,000	$4,000	
	Culvert/Pipe Easement (30"-48")	LF	943	$76	$71,668	
	Total Cost				$238,548	
AN	Remove Existing 30"	LF	80	$20	$1,600	B
	48" CMP	LF	110	$200	$22,000	
	48" End Section	EA	2	$2,500	$5,000	
	Total Cost				$28,600	
AO	Remove Existing 36"	LF	120	$30	$3,600	C
	48" CMP	LF	120	$200	$24,000	
	48" End Section	EA	2	$2,500	$5,000	
	Total Cost				$32,600	
AP	Remove Existing 30"	LF	80	$20	$1,600	C
	36" CMP	LF	80	$120	$9,600	
	36" End Section	EA	2	$1,600	$3,200	
	Total Cost				$14,400	
AQ	42" CMP	LF	1860	$160	$297,600	D

ID / Pond ID	Item Description	Unit	Quantity	Unit Cost ($)	Total Cost ($)	Priority
	Manhole	EA	5	$6,000	$30,000	
	42" End Section	EA	2	$2,000	$4,000	
	Channel Improvements (Medium)	LF	945	$60	$56,700	
	Culvert/Pipe Easement (30"-48")	LF	1860	$76	$141,360	
	Total Cost				$529,660	
AR	Remove Existing 18"	LF	110	$20	$2,200	E
	36" CMP	LF	110	$120	$13,200	
	36" End Section	EA	2	$1,600	$3,200	
	Channel Improvements (Medium)	LF	771	$60	$46,260	
	Total Cost				$64,860	
AS	36" CMP	LF	450	$120	$54,000	C
	36" End Section	EA	1	$1,600	$1,600	
	Manhole	EA	1	$6,000	$6,000	
	Channel Improvements (Small)	LF	1370	$45	$61,650	
	Total Cost				$123,250	
AT	72" Smooth Lined Pipe	LF	5270	$360	$1,897,200	A
	Manhole	EA	16	$6,000	$96,000	
	72" Headwall	EA	2	$12,000	$24,000	
	Culvert/Pipe Easement (72")	LF	1745	$90	$157,050	
	Total Cost				$2,174,250	
AU	Remove Existing 24”	LF	110	$20	$2,200	C
	30" CMP	LF	110	$110	$12,100	
	30" End Section	EA	2	$1,200	$2,400	
	Total Cost				$16,700	
AV	Remove Existing 30”	LF	90	$20	$1,800	A
	84" CMP	LF	110	$400	$44,000	
	84" Headwall	EA	2	$16,000	$32,000	
	Total Cost				$77,800	
AW	30" Smooth Lined Pipe	LF	2170	$120	$260,400	C
	Manhole	EA	6	$6,000	$36,000	
	30" End Section	EA	2	$1,200	$2,400	
	Culvert/Pipe Easement (30"-48")	LF	2170	$76	$164,920	
	Total Cost				$463,720	
AX	Remove Existing 24”	LF	80	$20	$1,600	E
	30" CMP	LF	80	$110	$8,800	
	30" End Section	EA	2	$1,200	$2,400	
	Total Cost				$12,800	
AY	Remove Existing 24"	LF	100	$20	$2,000	D
	60" CMP	LF	100	$240	$24,000	

ID / Pond ID	Item Description	Unit	Quantity	Unit Cost ($)	Total Cost ($)	Priority
	60" Headwall	EA	2	$8,000	$16,000	
	Channel Improvements (Large)	LF	1405	$80	$112,400	
	Total Cost				$154,400	
7	Detention Improvements	AC-FT	1	$16,500	$16,500	D
	Outlet Improvements	LS	1	$16,500	$16,500	
	Total Cost				$33,000	
8	Detention Basin	AC-FT	6.5	$24,200	$157,300	C
	42" CMP	LF	80	$120	$9,600	
	Spillway	LS	1	$10,000	$10,000	
	Outlet Structure	LS	1	$2,000	$2,000	
	Right-of-Way	AC	1.5	$300,000	$450,000	
	Total Cost				$628,900	
10	Detention Improvements	AC-FT	2.5	$16,500	$41,250	C
	Total Cost				$41,250	
11	Detention Basin	AC-FT	1.5	$24,200	$36,300	B
	24" CMP	LF	80	$60	$4,800	
	Outlet Structure	LS	1	$2,000	$2,000	
	Spillway	LS	1	$10,000	$10,000	
	Total Cost				$53,100	
12	Detention Basin	AC-FT	2	$24,200	$48,400	E
	24" CMP	LF	80	$60	$4,800	
	Spillway	LS	1	$10,000	$10,000	
	Outlet Structure	LS	1	$2,000	$2,000	
	Right-of-Way	AC	0.5	$300,000	$150,000	
	Total Cost				$215,200	
13	Detention Improvements	AC-FT	2	$16,500	$33,000	C
	Outlet Improvements	LS	1	$1,000	$1,000	
	Total Cost				$34,000	
14	Detention Improvements	AC-FT	1.6	$16,500	$26,400	C
	Outlet Improvements	LS	1	$17,500	$17,500	
	Total Cost				$43,900	
15a	Detention Improvements	AC-FT	1	$16,500	$16,500	E
	36" CMP	LF	80	$80	$6,400	
	Spillway	LS	1	$10,000	$10,000	
	Outlet Structure	LS	1	$2,000	$2,000	
	Total Cost				$34,900	
15b	Detention Improvements	AC-FT	2.5	$16,500	$41,250	C
	48" CMP	LF	80	$180	$14,400	
	Spillway	LS	1	$10,000	$10,000	

ID / Pond ID	Item Description	Unit	Quantity	Unit Cost ($)	Total Cost ($)	Priority
	Outlet Structure	LS	1	$2,000	$2,000	
	Total Cost				$67,650	
18	Detention Improvements	AC-FT	9.5	$16,500	$156,750	E
	54" CMP	LF	80	$200	$16,000	
	Spillway	LS	1	$10,000	$10,000	
	Outlet Structure	LS	1	$2,000	$2,000	
	Total Cost				$184,750	
19	Detention Basin	AC-FT	5.5	$24,200	$133,100	C
	30" CMP	LF	80	$70	$5,600	
	Spillway	LS	1	$10,000	$10,000	
	Outlet Structure	LS	1	$2,000	$2,000	
	Right-of-Way	AC	1	$300,000	$300,000	
	Total Cost				$450,700	
21	Detention Basin	AC-FT	3	$24,200	$72,600	D
	18" CMP	LF	80	$50	$4,000	
	Spillway	LS	1	$10,000	$10,000	
	Outlet Structure	LS	1	$2,000	$2,000	
	Right-of-Way	AC	0.5	$300,000	$150,000	
	Total Cost				$238,600	
29	Detention Basin	AC-FT	10.5	$24,200	$254,100	D
	36" CMP	LF	80	$80	$6,400	
	Spillway	LS	1	$10,000	$10,000	
	Outlet Structure	LS	1	$2,000	$2,000	
	Right-of-Way	AC	2	$300,000	$600,000	
	Total Cost				$872,500	
30	Detention Basin	AC-FT	20.5	$24,200	$496,100	E
	24" CMP	LF	80	$60	$4,800	
	Spillway	LS	1	$10,000	$10,000	
	Outlet Structure	LS	1	$2,000	$2,000	
	Right-of-Way	AC	3.5	$300,000	$1,050,000	
	Total Cost				$1,562,900	
32	Detention Basin	AC-FT	1.5	$24,200	$36,300	F
	18" CMP	LF	80	$50	$4,000	
	Spillway	LS	1	$10,000	$10,000	
	Outlet Structure	LS	1	$2,000	$2,000	
	Right-of-Way	AC	1	$300,000	$300,000	
	Total Cost				$352,300	
34	Detention Basin	AC-FT	3	$24,200	$72,600	F
	36" CMP	LF	80	$80	$6,400	

ID / Pond ID	Item Description	Unit	Quantity	Unit Cost ($)	Total Cost ($)	Priority
	Spillway	LS	1	$10,000	$10,000	
	Outlet Structure	LS	1	$2,000	$2,000	
	Right-of-Way	AC	1	$300,000	$300,000	
		Total Cost			$391,000	
37	Detention Basin	AC-FT	3	$24,200	$72,600	F
	24" CMP	LF	80	$60	$4,800	
	Spillway	LS	1	$10,000	$10,000	
	Outlet Structure	LS	1	$2,000	$2,000	
	Right-of-Way	AC	1	$300,000	$300,000	
		Total Cost			$389,400	
40	Detention Basin	AC-FT	5.5	$24,200	$133,100	F
	36" CMP	LF	80	$80	$6,400	
	Spillway	LS	1	$10,000	$10,000	
	Outlet Structure	LS	1	$2,000	$2,000	
	Right-of-Way	AC	1.5	$300,000	$450,000	
		Total Cost			$601,500	
50	Detention Basin	AC-FT	2.5	$24,200	$60,500	A
	36" CMP	LF	80	$80	$6,400	
	Spillway	LS	1	$10,000	$10,000	
	Outlet Structure	LS	1	$2,000	$2,000	
	Right-of-Way	AC	1	$300,000	$300,000	
		Total Cost			$378,900	
54	Detention Improvements	AC-FT	3	$16,500	$49,500	A
	Outlet Improvements	LS	1	$18,000	$18,000	
		Total Cost			$67,500	
58	Detention Basin	AC-FT	1	$24,200	$24,200	E
	18" CMP	LF	80	$50	$4,000	
	Spillway	LS	1	$10,000	$10,000	
	Outlet Structure	LS	1	$2,000	$2,000	
	Right-of-Way	AC	0.5	$300,000	$150,000	
		Total Cost			$190,200	
66	Detention Basin	AC-FT	6	$24,200	$145,200	D
	24" CMP	LF	80	$60	$4,800	
	Spillway	LS	1	$10,000	$10,000	
	Outlet Structure	LS	1	$2,000	$2,000	
	Right-of-Way	AC	1.5	$300,000	$450,000	
		Total Cost			$612,000	
70	Detention Improvements	AC-FT	3	$16,500	$49,500	A
	Outlet Improvements	LS	1	$1,000	$1,000	

ID / Pond ID	Item Description	Unit	Quantity	Unit Cost ($)	Total Cost ($)	Priority
	Total Cost				$50,500	
73	Detention Basin	AC-FT	2.5	$24,200	$60,500	D
	18" CMP	LF	80	$50	$4,000	
	Spillway	LS	1	$10,000	$10,000	
	Outlet Structure	LS	1	$2,000	$2,000	
	Right-of-Way	AC	0.5	$300,000	$150,000	
	Channel Improvements (Small)	LF	1060	$45	$47,700	
	Total Cost				$274,200	
75	Detention Basin	AC-FT	20	$24,200	$484,000	B
	30" CMP	LF	80	$70	$5,600	
	Spillway	LS	1	$10,000	$10,000	
	Outlet Structure	LS	1	$2,000	$2,000	
	Channel Improvements (Large)	LF	220	$80	$17,600	
	Right-of-Way	AC	2.5	$300,000	$750,000	
	Total Cost				$1,269,200	
84	Detention Basin	AC-FT	6	$24,200	$145,200	C
	24" CMP	LF	80	$60	$4,800	
	Spillway	LS	1	$10,000	$10,000	
	Outlet Structure	LS	1	$2,000	$2,000	
	Right-of-Way	AC	1.5	$300,000	$450,000	
	Total Cost				$612,000	
90	Detention Basin	AC-FT	13	$24,200	$314,600	F
	30" CMP	LF	80	$70	$5,600	
	Spillway	LS	1	$10,000	$10,000	
	Outlet Structure	LS	1	$2,000	$2,000	
	Right-of-Way	AC	2.5	$300,000	$750,000	
	Total Cost				$1,082,200	
98	Detention Basin	AC-FT	5.5	$24,200	$133,100	A
	24" CMP	LF	80	$60	$4,800	
	Spillway	LS	1	$10,000	$10,000	
	Outlet Structure	LS	1	$2,000	$2,000	
	Right-of-Way	AC	1	$300,000	$300,000	
	Total Cost				$449,900	
99	Detention Basin	AC-FT	9	$24,200	$217,800	A
	30" CMP	LF	80	$70	$5,600	
	Spillway	LS	1	$10,000	$10,000	
	Outlet Structure	LS	1	$2,000	$2,000	
	Right-of-Way	AC	1.5	$300,000	$450,000	
	Channel Improvements (Medium)	LF	391	$60	$23,460	

ID / Pond ID	Item Description	Unit	Quantity	Unit Cost ($)	Total Cost ($)	Priority
	ROW Medium Channel	LF	391	$276	$107,916	
	Total Cost				$816,776	
103	Detention Basin	AC-FT	2	$24,200	$48,400	B
	24" CMP	LF	80	$60	$4,800	
	Spillway	LS	1	$10,000	$10,000	
	Outlet Structure	LS	1	$2,000	$2,000	
	Right-of-Way	AC	0.5	$300,000	$150,000	
	Total Cost				$215,200	
110	Detention Basin	AC-FT	2.5	$24,200	$60,500	D
	18" CMP	LF	80	$50	$4,000	
	Spillway	LS	1	$10,000	$10,000	
	Outlet Structure	LS	1	$2,000	$2,000	
	Right-of-Way	AC	1	$300,000	$300,000	
	Total Cost				$376,500	
111	Detention Improvements	AC-FT	5	$16,500	$82,500	A
	Outlet Improvements	LS	1	$63,500	$63,500	
	Total Cost				$146,000	
113	Detention Basin	AC-FT	6.5	$24,200	$157,300	B
	18" CMP	LF	80	$50	$4,000	
	Spillway	LS	1	$10,000	$10,000	
	Outlet Structure	LS	1	$2,000	$2,000	
	Right-of-Way	AC	1.5	$300,000	$450,000	
	Channel Improvements (Small)	LF	1180	$45	$53,100	
	Channel Improvements (Medium)	LF	1235	$60	$74,100	
	Total Cost				$750,500	
116	Detention Basin	AC-FT	6.5	$24,200	$157,300	A
	42" CMP	LF	80	$120	$9,600	
	Spillway	LS	1	$10,000	$10,000	
	Outlet Structure	LS	1	$2,000	$2,000	
	Right-of-Way	AC	1.5	$300,000	$450,000	
	Channel Improvements (Large)	LF	1190	$80	$95,200	
	Total Cost				$724,100	
117	Detention Basin	AC-FT	10	$24,200	$242,000	B
	42" CMP	LF	80	$120	$9,600	
	Spillway	LS	1	$10,000	$10,000	
	Outlet Structure	LS	1	$2,000	$2,000	
	Right-of-Way	AC	2	$300,000	$600,000	
	Total Cost				$863,600	

ID / Pond ID	Item Description	Unit	Quantity	Unit Cost ($)	Total Cost ($)	Priority
Other Channel Improvements (not included with labeled improvements)						
	Channel Improvements (Small)	LF	6800	$45	$306,000	
	Channel Improvements (Medium)	LF	1975	$60	$118,500	
	Channel Improvements (Large)	LF	110	$80	$8,800	
	Total Cost				$433,300	
	Sub Total of A & B Prioritized Improvements				$9,903,426	
	Contingency (15%)				$1,485,514	
	Mobilization (10%)				$990,343	
	PreConstruction Engineering (12%)				$1,188,411	
	Construction Engineering (12%)				$1,188,411	
	Environmental (10%)				$990,343	
	Legal (5%)				$495,171	
	Total Cost of A & B Prioritized Improvements				**$16,241,619**	
	Sub Total of all Improvements				$23,588,118	
	Contingency (15%)				$3,538,218	
	Mobilization (10%)				$2,358,812	
	PreConstruction Engineering (12%)				$2,830,574	
	Construction Engineering (12%)				$2,830,574	
	Environmental (10%)				$2,358,812	
	Legal (5%)				$1,179,406	
	Total Cost of all Improvements				**$38,684,514**	

Indexed to ENR CCI = 8566, July 2009.

The above cost estimates are based on August 2009 construction cost and right-of-way estimates. Right-of-way and easement costs have been included for detention basins and other major drainage improvements where the need was evident. Other improvements may also need right-of-way and easement acquisition, depending on location and alignment.

5 FUNDING MECHANISMS

The construction of valley-wide storm water management facilities will require financial resources. These funds will be needed for the detailed hydrologic and hydraulic modeling, design and construction of such facilities and for their operation and maintenance. This chapter will discuss funding as it relates to capital improvements, and system operations and maintenance. It will also discuss five sources of funding which include taxes, grants, utility fees, impact fees, and the creation of a special improvement district.

5.1 CAPITAL IMPROVEMENTS

The storm water management system will require capital improvements to function to the level of service defined earlier. Some of the capital improvements will need to be completed in somewhat of a timely manner. The funding for these improvements could be taken from the County's general funds, it could be bonded for and paid off at a later date, or the improvements could be done as the funds are generated.

5.2 OPERATIONS AND MAINTENANCE

The operation and maintenance (O&M) will require a fairly steady income. O&M funds could be taken from the County's general funds or from a utility fee. Utah law does not allow the use of impact fees for the operation and maintenance costs.

5.3 TAXES

One method of generating the necessary funds is through taxes. Taxes tend to fund the general operations of the county and any other expenses deemed necessary by county officials. Existing funds could be allocated to the capital improvements and/or operations and maintenance, or new funds could be generated for this purpose.

5.4 GRANTS

The State and Federal Government does have available funds from time to time for a wide variety of improvements. These are often linked to a specific purpose or benefit. It may be possible to install some of the storm drain system improvements in conjunction with these types of projects where applicable.

5.5 UTILITY FEES

Another method of generating funds is through a utility fee. A storm water management utility fee could be used to generate funds for capital improvements, operations and maintenance, and general system repairs and upgrades. The utility fee could be easily changed to accommodate the changing financial needs of the storm water management system.

If operation and maintenance costs are included in the utility fee, a true operation and maintenance fee would need to be developed based on actual expenses. It is felt that a fee of about $1.00 per equivalent residence per month would be adequate for this purpose. Utility fees could start low and increase over time as new facilities are constructed. With additional facilities come increased costs to maintain the drainage system. Table 5-1 shows a comparison of utility fees in the western United States. It is possible that the higher fees listed include capital improvement funding.

Table 5-1: Utility Fees in the Western United States

Location	Amount/Month	Location	Amount/Month
Alpine, UT	$3.30	Springville, UT	$3.96
Brigham City, UT	$6.62	Syracuse, UT	$3.50
Farmington, UT	$7.00	West Valley City, UT	$4.00
Murray, UT	$3.55	Woods Cross, UT	$1.00
Orem, UT	$4.75	Evanston, WY	$0.50
Payson, UT	$5.00	Bend, OR	$4.00
Provo, UT	$4.19	Fort Worth, TX	$3.75
Spanish Fork, UT	$4.50	Oro Valley, AZ	$2.90

Obtained from each city's website, August 2009.

5.6 Impact Fees

Grand County currently has a storm water impact fee of $324.08 per ERU, as updated in 2004. No adjustments have been made since that time to account for inflation or other factors. Adjusting for inflation alone would increase the fee to $390, based on a 20.3% increase as obtained from the Engineering News-Record (ENR) Construction Cost Index from July 2004 to July 2009. An adjustment to the impact fee may be appropriate.

Utah law establishes a specific process for the determination and levy of an impact fee. A written impact fee analysis is required by statute. Political subdivisions with a population of 5,000 or more as of the last Federal Census must complete a capital facilities plan as part of the impact fee process and as input to the impact fee analysis. The population of Grand County as of the last Federal Census was 8,485. Excluding Moab City and the town of Castle Valley, the remaining Grand County population was 3,252. The Utah Governor's Office of Planning and Budget's 2008 population estimate for Grand County (excluding Moab City and the town of Castle Valley) is 4,082. It appears that as of the next Federal Census that the population of Grand County (excluding Moab City and the town of Castle Valley) will still be below the 5,000 threshold. However, the statute does require that impact fees be based on a reasonable plan [Section 11-36-201(2)(f)].

The County may choose to do a capital facilities plan because their population is approaching the threshold. Much of the data that was prepared for this Storm Drain Master Plan Update is applicable to a capital facilities plan and would allow easy preparation of such a plan. If the County chooses to not do a capital facilities plan, the Storm Drain Master Plan would be the basis for the "reasonable plan" as described by the statute and would provide much of the needed information for the impact fee analysis.

5.7 Special Improvement District

Similar to using a utility fee to raise funds for capital improvements, a special improvement district would allow the County to allocate that portion of the cost of the entire recommended system which should be paid by both the existing and future population to all benefitted properties. These funds could be made collectable when the land is developed, or over a period of several years for the areas already developed. This option provides an alternative to using a utility fee to raise funds for capital, but it may require the support of the local voters. The cost for commercial and industrial development could be increased because these areas tend to generate more storm water management problems.

5.8 Funding Recommendations

It is recommended that Grand County establish a clear funding mechanism to pay for the on-going operations and maintenance costs of the storm water system.

It is recommended that Grand County perform an Impact Fee Analysis and comply with other requirements of the Utah Impact Fee statute in order to update its current storm water impact fee. This will provide the County with the ongoing ability to fund storm drain improvements and assign fair and appropriate financial responsibility for those improvements.

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