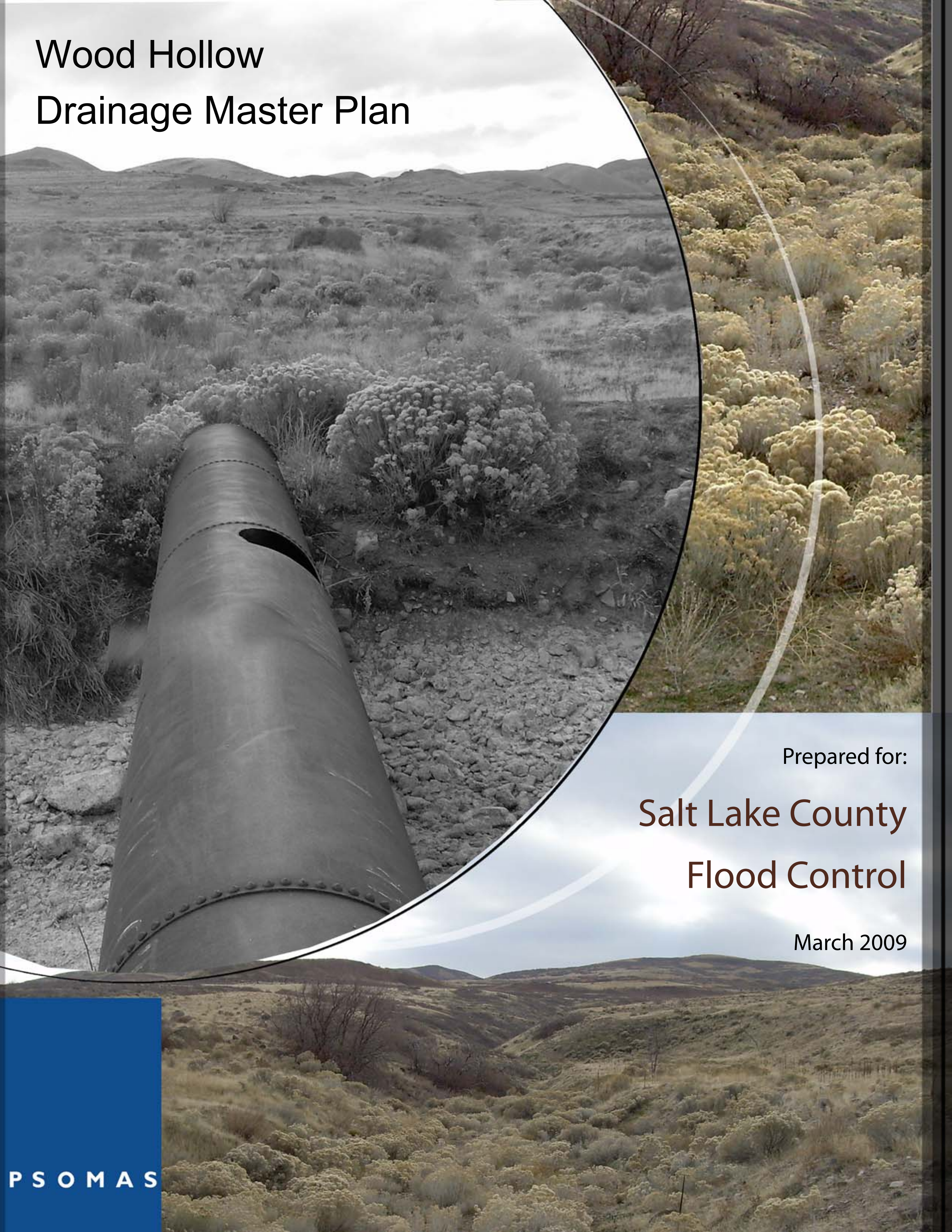
Wood Hollow Drainage Master Plan



Prepared for:

Salt Lake County Flood Control

March 2009

PSOMAS

WOOD HOLLOW

MASTER PLAN

FINAL REPORT

PREPARED FOR:

SALT LAKE COUNTY ENGINEERING, FLOOD CONTROL

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Section 1 - Executive Summary

1.1 Background and Existing Conditions

The Wood Hollow study area consists of a relatively large portion of land in the southwest corner of Salt Lake County that is located on the benches of the Oquirrh Mountains (see Figure 1).

The most downstream portions of the watershed's natural stream have been considerably altered by impacts of development. Several man-made structures have been constructed across the drainage with minimal efforts to maintain the historical drainage patterns and characteristics.

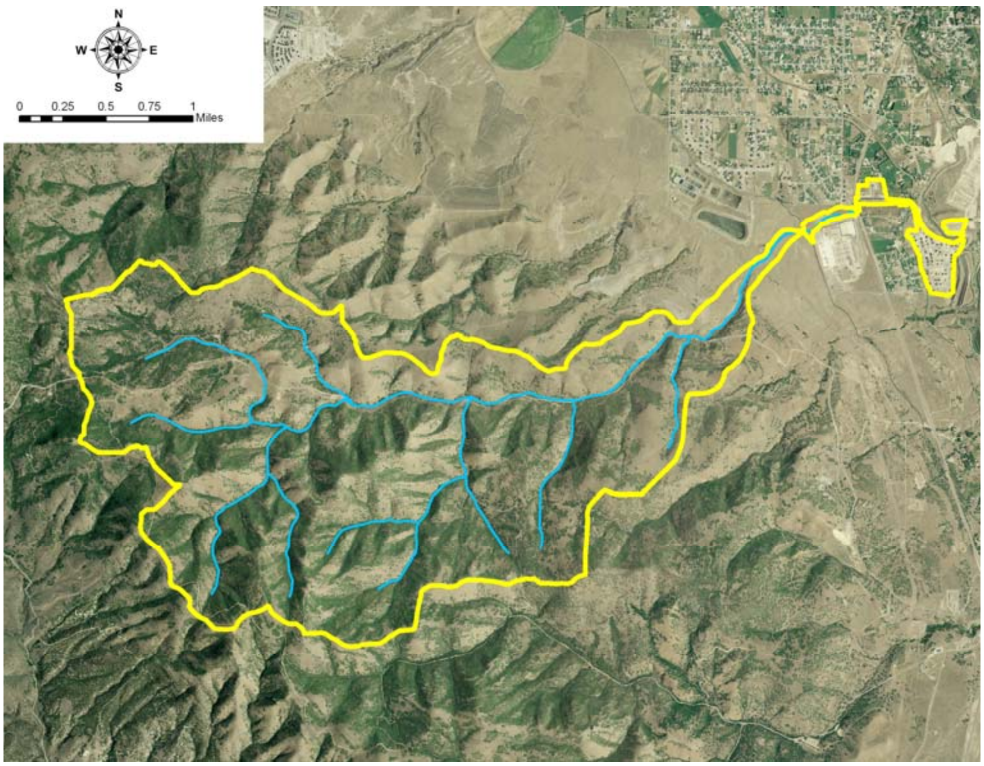

Figure 1. The existing Wood Hollow watershed shown on 2006 NAIP aerial.

1.2 Purpose and Objective

In an effort to provide for adequate flood control in this drainage area, the Division of Flood Control is attempting to restore, improve, and/or construct new facilities which would allow for restored conveyance of Wood Hollow flows to the Jordan River. The primary purpose of this study is to perform a hydrologic and hydraulic analysis and recommendations for the Wood Hollow drainage area which will establish design parameters for any subsequent designs of drainage improvements within it.

1.3 Hydrologic Analysis

Peak discharge values and runoff volumes were obtained from the model at the critical locations and are listed in Table 1 and Table 2, respectively. The highest peak discharge is produced during the 100-year, 12-hour event for both the existing and future scenarios. Based on the computed results an average cfs/acre runoff production value of 0.05 is extracted.

Table 1. Peak discharge values at selected locations.

Location	100 Year Peak Discharge Q (cfs)									
	Existing					Future				
	1-Hour	3-Hour	6-Hour	12-Hour	24-Hour	1-Hour	3-Hour	6-Hour	12-Hour	24-Hour
Provo-Reservoir Canal	16	68	85	140	126	96	141	99	173	155
Redwood Road	16	68	85	141	126	96	141	99	174	155
Parry Farms Detention Pond	24	68	88	147	132	115	172	105	178	160

Table 2. Runoff volume values at selected locations.

Location	100 Year Runoff Volume (ac-ft)									
	Existing					Future				
	1-Hour	3-Hour	6-Hour	12-Hour	24-Hour	1-Hour	3-Hour	6-Hour	12-Hour	24-Hour
Provo-Reservoir Canal	3	11	20	54	75	25	44	61	112	142
Redwood Road	3	11	20	54	76	25	44	61	112	143
Parry Farms Detention Pond	4	13	23	58	81	27	47	64	117	149

In an effort to better substantiate model results, a comparison of other studies in the general area was performed. The comparison indicated that some of these studies used methods similar or comparable to those used in this report (e.g., SCS/NRCS methods). A summary of the existing peak values obtained from the comparison studies for the Provo-Reservoir Canal location is given in Table 3.

Table 3. Study comparison for existing peak discharge at the Provo-Reservoir Canal.

Study	Existing Peak Discharge (cfs)
NFF	153
2002 BC&A Study	115
Psomas	140

The results obtained from this study are consistent with previous study results and the regression NFF equation. As such, it is noted that the often-encountered 0.2 cfs/acre is somewhat higher than what the land in this area appears to produce in terms of 100-year runoff values. It is strongly recommended that the estimated future peak discharge values, as indicated in this report, be used for planning and design efforts. It is also recommended that any future developments in the Wood Hollow watershed consider the results of this study and understand the approach and assumptions made.

1.4 Inventory of Existing Conditions

As shown in Exhibit 1, there are seven existing conditions that keep the Wood Hollow runoff from reaching its historic confluence with the Jordan River. The following seven conditions and their respective capacities are listed as follows.

1. Service road crossing #1 (0 cfs)
2. Service road crossing #2 (0 cfs)
3. Provo-Reservoir Canal crossing (20 cfs)
4. Open channel in the power plant area (30.9 cfs)
5. Camp Williams Road crossing (80 cfs)
6. Iron Horse Boulevard storm drain system (82 cfs)
7. Parry Farms detention pond (not yet determined)

As indicated in Table 1, the peak discharge from the Wood Hollow watershed will yield over 170 cfs under future conditions. This poses a problem as all the existing facilities are inadequate as indicated by their existing capacities.

It is understood that the County intends to continue this study to determine the existing conditions of the Parry Farms detention pond in order to ensure safe conveyance of Wood Hollow runoff to the Jordan River.

1.5 Alternative Development

Four alternatives are presented in this report starting on page 37. Each alternative proposes feasible options and improvements that mitigate the deficiencies of the existing conditions mentioned above. The alternatives and their respective names are listed as follows:

- Alternative 1 - Large Regional Detention
- Alternative 2 - Small Regional Detention, Additional Storm Drain Line
- Alternative 3 - Small Regional Detention, Upsize Storm Drain Line
- Alternative 4 - Small Regional Detention, Parallel Storm Drain Line

1.6 Preferred Alternative

As directed by the County, the alternative with the least estimated project cost is the preferred alternative. As such, Alternative 2 is the preferred alternative.

Table 4. Alternative Cost Summary

Alternative Project *Cost (Million Dollars)			
1	2	3	4
$3.01	$1.70	$2.25	$1.76

1.7 Proposed Improvements for Preferred Alternative

In general, the preferred alternative follows the alignment as illustrated in Figure 2 below. The alternative considers a 7.6 ac-ft regional detention pond and proposes construction of another storm drain line in the parcels south of Iron Horse Boulevard.

Figure 2. Alternative 2 Summary over 2006 aerial

Total estimated cost of this alternative is 1.70 million dollars detailed in Appendix G.

Section 2 - Introduction

2.1 Background and Existing Conditions

The Wood Hollow study area consists of a relatively large portion of land available for development within the southwest corner of Salt Lake County that is located on the benches of the Oquirrh Mountains. Currently, most of the study area has kept its rural and undeveloped character. Due to expected future development, the hydrologic conditions and drainage characteristics of the area will experience change and are expected to transition to a more urbanized environment. In an effort to mitigate the effects of anticipated development, the Engineering Division of Salt Lake County Public Works is actively trying to improve the existing flood control facilities under their jurisdiction. The Wood Hollow drainage is one of the larger natural streams identified as a flood control facility in the County's jurisdiction. The drainage includes portions of Herriman and Bluffdale City and some unincorporated county areas. Historically, approximately 3,500 acres (over 5 square miles) stretching from the lower Oquirrh Mountains above the Jordan Narrows in the west to the Jordan River in the east drained through Wood Hollow and ultimately into the Jordan River. The upper portions of this drainage are currently relatively unaffected by development and have kept many of their natural characteristics (see Figure 3).

Figure 3. Looking west (upstream) from a location near the Provo-Reservoir (Welby-Jacobs) Canal crossing.

As illustrated by comparing Figure 4 and Figure 5, the most downstream portions of the watershed's natural stream have been considerably altered by impacts of development. Several man-made structures have been constructed across the drainage with minimal efforts to maintain the historical drainage patterns and characteristics.

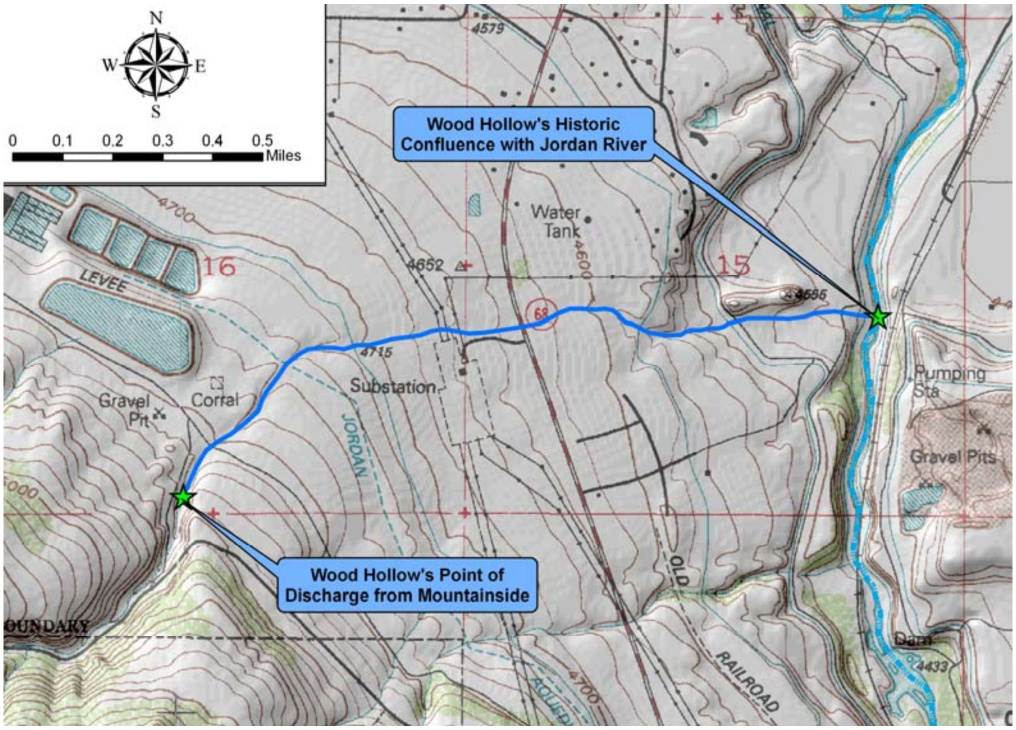

Figure 4. Wood Hollow's historic flow path to Jordan River over USGS Quadrangle map

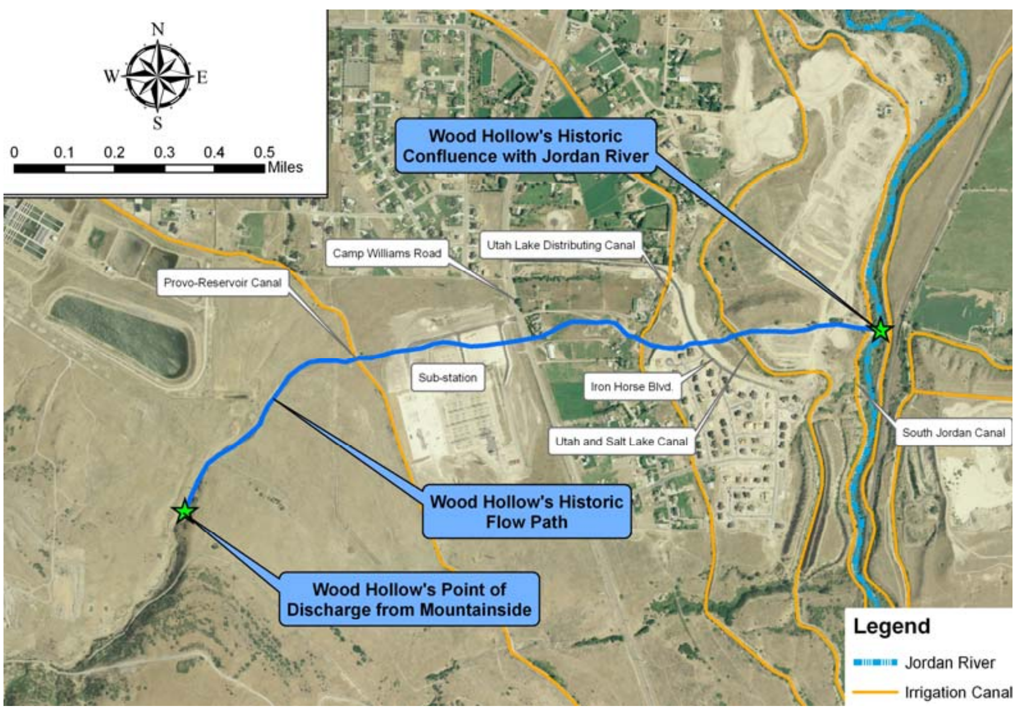

Figure 5. Wood Hollow's historic flow-path over 2006 NAIP aerial photograph

In addition, the historic Wood Hollow drainage has been altered in the areas east of the Provo-Reservoir Canal (also known as the Welby-Jacobs Canal) and little evidence exists that flows generated in the Wood Hollow drainage are conveyed to the historical outfall point at the Jordan River.

2.2 Purpose and Objectives

In an effort to provide adequate flood control in this drainage area, the Division of Flood Control is attempting to restore, improve, and/or construct new facilities which would allow for restored conveyance of Wood Hollow flows to the Jordan River. The primary purpose of this study is to perform a hydrologic and hydraulic analysis and recommendations for the Wood Hollow drainage area which will establish design parameters for any subsequent designs of drainage improvements within it.

The focus of this study is to;

- Gather information including topography, precipitation data, land use, hydrologic soil types, important hydrographic features (watercourses and impoundments) as well as available information on hydraulic structures and base flows.
- Review previous studies and reports. Consequently, some effort has been made in this study to be consistent with the approach, results, and parameters denoted in previous applicable studies.
- Determine the appropriate hydrologic approach and methodology using applicable County guidelines and other standard and commonly accepted methods.
- Build HEC-HMS models to asses the precipitation-runoff response for existing and future conditions for a 100-year (1 percent probability) storm event and perform a duration-sensitivity analysis to determine the governing storm duration out of the 1, 3, 6, 12, and 24-hour storms.
- Determine peak flows at points of interest which will be used for subsequent design efforts.
- Identify drainage alternatives for conveyance of the Wood Hollow flows to the Jordan River.
- Propose key improvements to convey Wood Hollow flows to the Jordan River.

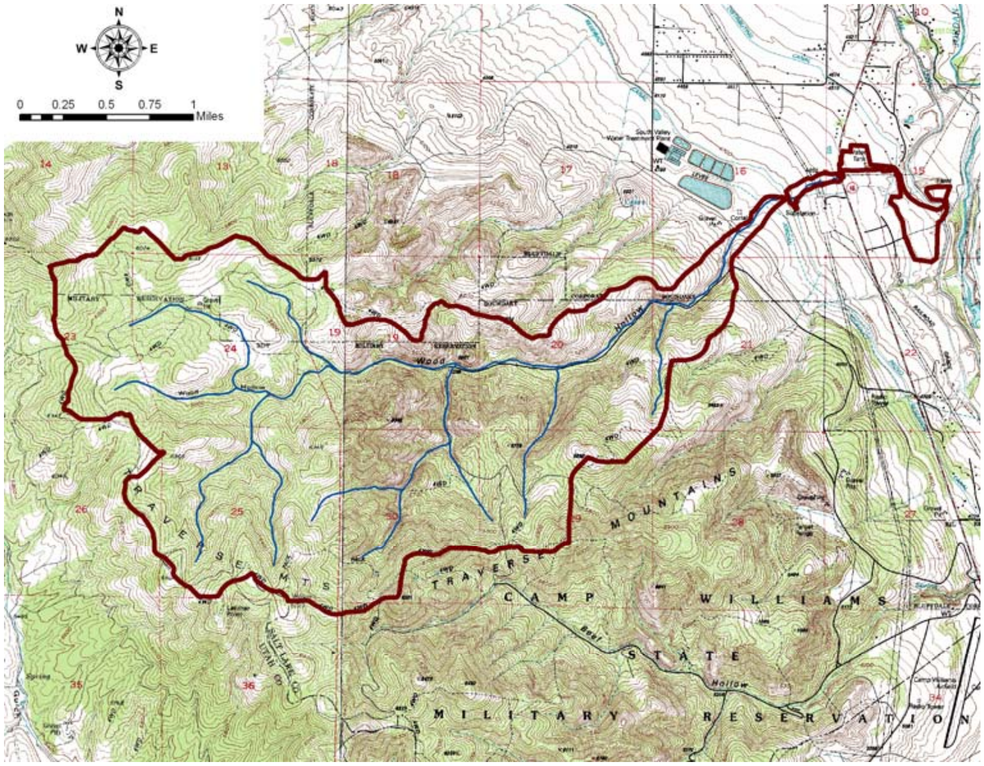

Figure 6. The existing Wood Hollow watershed tributary shown on a USGS quadrangle map.

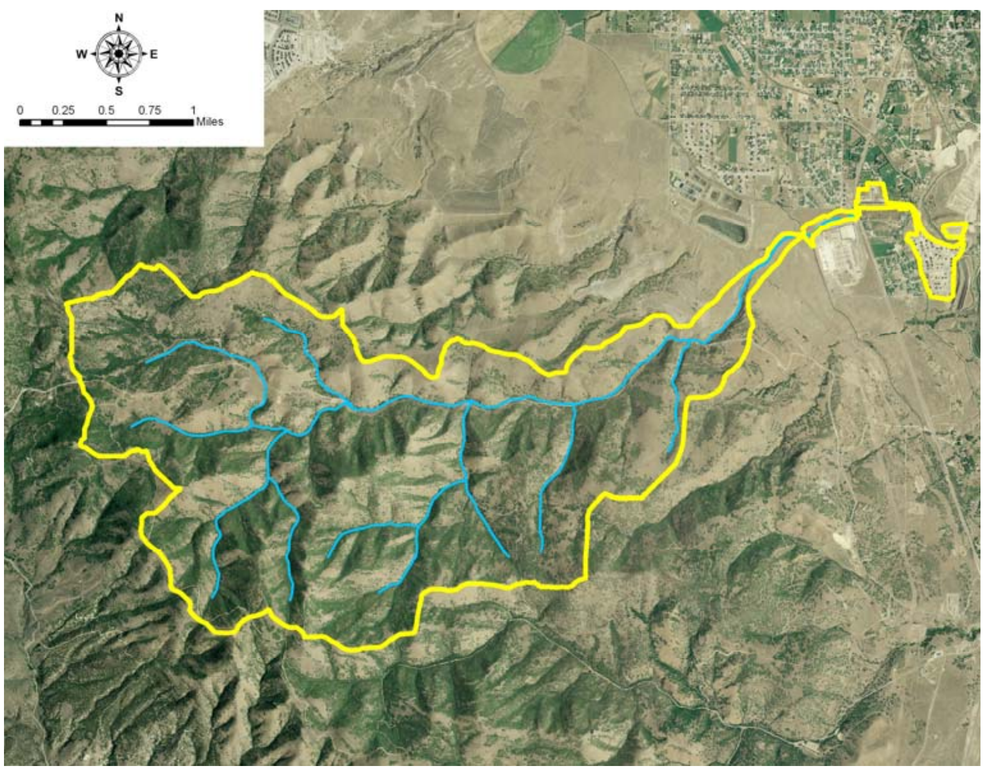

Figure 7. The existing Wood Hollow watershed shown on 2006 NAIP aerial.

2.3 Previous Studies

Other reports directly related to the hydrology, stormwater, and/or drainage of the area were available at the time this study was completed and listed below. Each of these particular works are listed below. These previous studies, each having a slightly different purpose, were reviewed as appropriate for applicability to this study. Nevertheless, the purpose and goal of this effort was to provide an independent and objective study.

- Bowen, Collins, & Associates, Inc., Southwest Canal and Creek Study Volume 1 of 2, April, 2003.
- Stantec, Storm Drainage Pipe and Pond Sizing Calculations-Parry Farms Phase 1, September, 2005.
- Nolte Associates, Inc, Rosecrest & South Hills Development-Storm Drain Master Plan, November, 2006.

A variety of other less-specific publications, texts, and references were also used for this study and are listed in the final section of this report. Some of them are discussed in more detail in the Hydrologic Results. This study relied upon technical works and data developed or provided by others, and no independent validation or verification of those items is part of this study. As such, Psomas shall not be held responsible or liable for use of work prepared by others.

Section 3 - Hydrologic Analysis

3.1 Approach and Methodology

The technical approach selected for this study consists of a combination of several items, namely:

- Current standard practices in applied hydrology for this region,
- Hydrologic analysis methods appropriate and common for drainage studies of this size,
- A certain degree of consideration for methods used in the original and other previous studies and analyses (while preserving objectivity).

This study is regional in nature, and is not tied to any particular municipality or specific development as portions of this watershed are found in Bluffdale City, Herriman City, and unincorporated Salt Lake County areas. Furthermore, this study has a particular focus on several specific locations within the Wood Hollow drainage (see Figure 4 on 2). That is, the results from this hydrology study (e.g., peak flow rates and runoff volumes) are assessed and presented with special emphasis on the specific locations which have been indentified as critical for subsequent design alternatives.

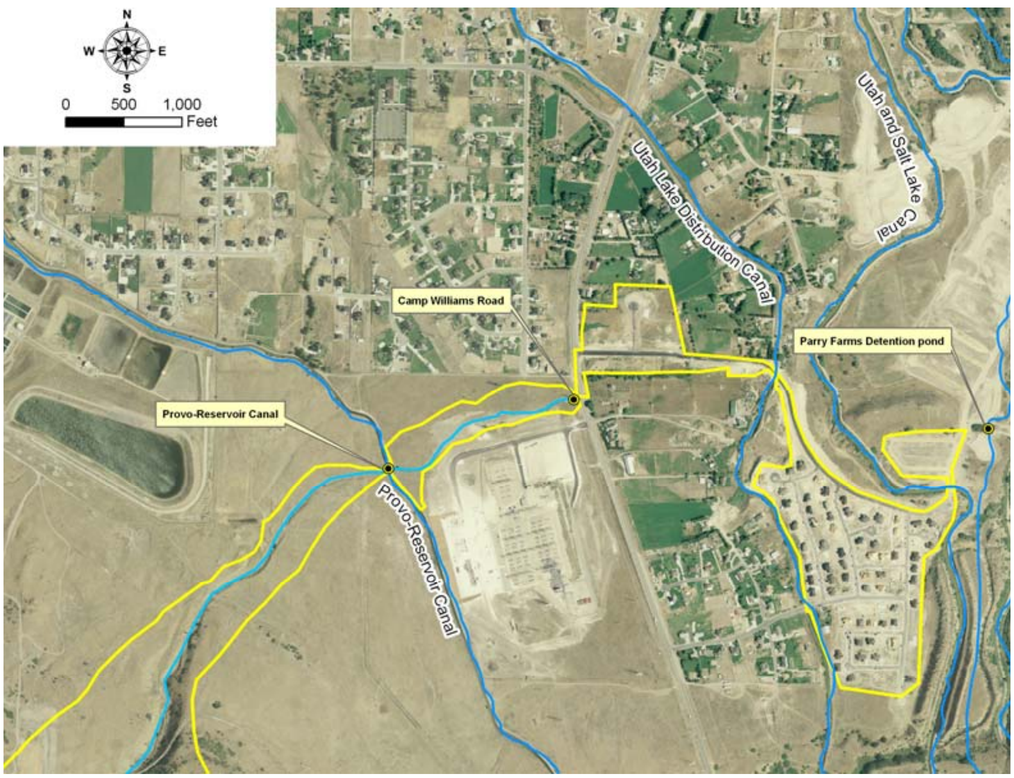

Figure 8. Locations of interest in the Wood Hollow watershed.

It is also noted that the purpose of this study is to characterize the flow rates and runoff volumes that are entering, or will enter into the Wood Hollow drainage.

3.1.1 Hydrography

Wood Hollow is the main natural stream in this drainage area. Due to the agricultural history and nature of the area, three irrigation channels traverse the area (see Figure 4 on page 2). They are:

- Provo-Reservoir Canal
- Utah Lake Distributing Canal
- Utah and Salt Lake Canal

The Provo-Reservoir Canal is the most upstream canal in the Wood Hollow drainage. Some previous efforts have been made to ensure that the Wood Hollow flows are conveyed across the Provo-Reservoir Canal through a 40-inch diameter steel pipe across the canal as shown in the figure below. Based on the field observations, there is no evidence indicating that this structure serves its purpose. That is, the conditions on the inlet side of the pipe do not appear to allow all the Wood Hollow flows to be directed into the pipe. As such, it is assumed that the majority of Wood Hollow flows are intercepted by the Provo-Reservoir Canal.

Figure 9. Steel pipe intended to convey substantial Wood Hollow drainage flows across the Provo-Reservoir canal.

Consequently, the character of the drainage changes significantly beyond this point. Between the Provo-Reservoir canal and Camp Williams Road, the Wood Hollow drainage has also been altered by the construction of a nearby power substation. In this reach, a man-made channel has been constructed and the drainage appears to be different from its historic path. East and downstream of Camp Williams Road, the Parry Farms development has been constructed. In this area, it is difficult to find any evidence of the historical Wood Hollow drainage. Adjacent to this development, a storm drain system was constructed, in Iron Horse Road, with the intent to provide enough capacity to convey Wood Hollow flows to the Jordan River.

3.1.2 Precipitation-Runoff Response

It is important to understand that the only true way to assess flow rates for different return periods (e.g., the 100-year *flow*) is to obtain adequate (i.e., long-term) and accurate flow data. In most cases, adequate flow data is not available which is especially true in urban settings. In this case, a wide variety of methods have been developed to estimate peak discharge for a specific precipitation event. Without extensive runoff records to compare and calibrate, peak discharges and runoff volumes can become more difficult to estimate, and professional experience and judgment become vital.

This report and the associated model have quantified peak discharge rates on the basis of design storms (discussed in more detail in Section 3.1.9). In addition, several durations were used to help establish the controlling or governing duration.

3.1.3 Snowmelt and Base Flow

This study primarily assessed the precipitation-runoff response from a single storm event. In-stream losses were not considered as part of this study, and a detailed assessment of stream base flows due to groundwater and/or snowmelt runoff was also not part of this study. During several site visits, base flows were absent in the lower areas of the watershed.

3.1.4 Topographic Data

Two sources of topographic data were used in this study. For the lower areas of the drainage basin, data obtained from the Salt Lake County Surveyors Office was used. This data was in form of 2-meter contours. The spatial extent of this particular data set is shown in Figure 6. The elevation and terrain data for all other upstream areas of the watershed was obtained from the most recent 10-meter USGS Spatial Data Transfer Standard (SDTS) Digital Elevation Models (DEM). Elevations corresponded to the National Geodetic Vertical Datum of 1929 (NGVD29). This data was used in a variety of ways, including the development of a Digital Terrain Model (DTM) used to determine mean elevations, elevation contours, slopes, flow paths, flow patterns, and other parameters important to the analysis. This terrain data was also helpful for the delineation of the overall watershed and sub-basins, particularly in areas not impacted by urbanization and storm drain systems.

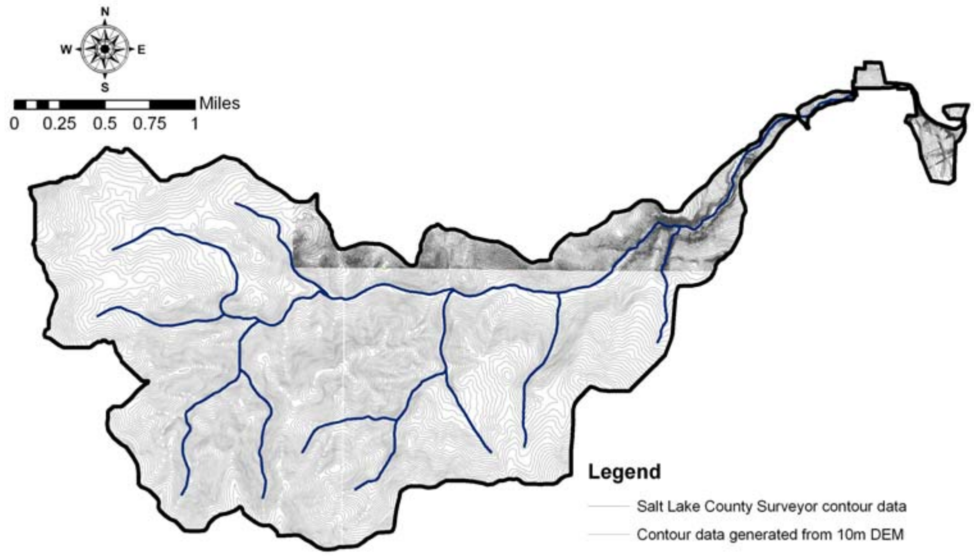

Figure 10. Spatial extents of different contour data sets.

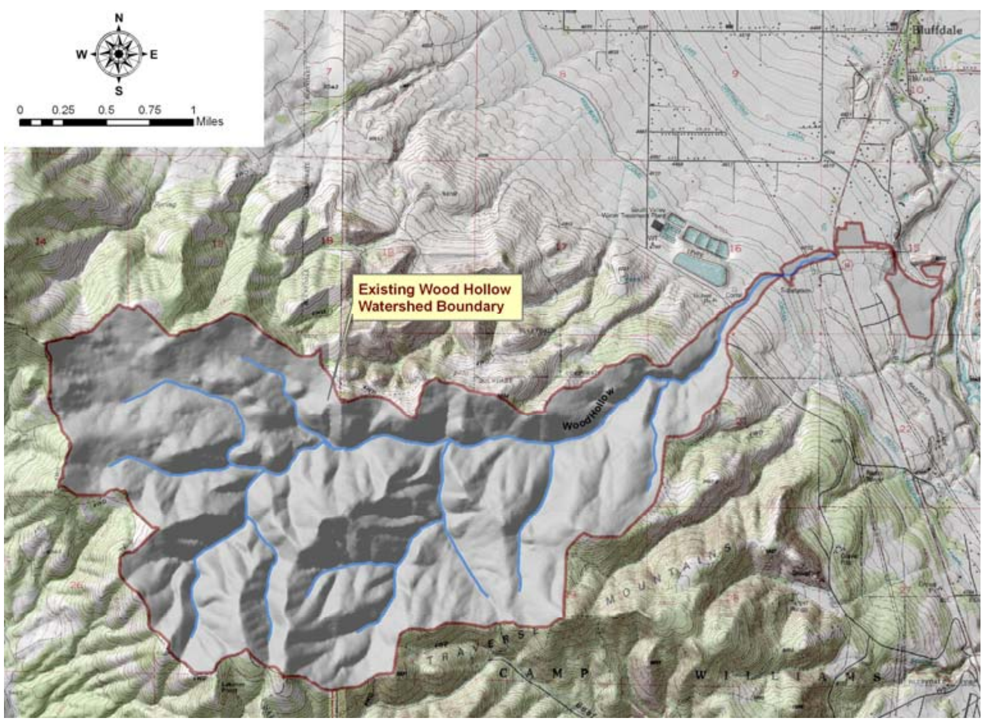

Figure 11. The existing Wood Hollow watershed boundary over hill-shade.

3.1.5 Basin Delineation

The overall Wood Hollow watershed was further divided into nine exiting sub-basins and 16 future sub-basins. This provided for a less lumped-parameter model and for more of a distributed model. Concentration points for each sub-basin were selected based on several factors and criteria. These factors included an effort to provide a degree of uniformity in the size, shape, and properties of each sub-basin. Properties such as land use, soil type, slope, diversion structures, roadways, and storm drain systems were also considered. Finally, concentration points are also selected at locations of analysis interest and at confluence points. For existing conditions, sub-basins were developed using terrain and topographical data, as well as information on the storm drain system constructed in the Parry Farms. In order to delineate the future conditions basins, additional sources were used to establish future land use characteristics and also incorporate changes in drainage patterns caused by planned developments. In some cases information provided in theses sources was directly used to delineate the future basins (Rosecrest, South Hills, and Mountain View Corridor basins). The future conditions scenario includes a portion of the Mountain View Corridor which is still in the preliminary design phase. According to the information received from the Utah Department of Transportation (UDOT), the alignment of the corridor in the area of interest is still not finalized. However, the current UDOT design shows approximately 205 acres of Mountain View Corridor draining to Wood Hollow as more fully explained later in the report. Consequently, for the future conditions scenario, additional sub-basins were created and/or some basin boundaries were altered. The location of concentration points (points of interest) was maintained as much as possible to offer benchmarks for comparison between existing and future conditions. Existing sub-basin delineations are shown in with those for future conditions in Figure 13. Areas for each sub-basin are listed in Table 5.

Table 5. Sub-basin area for existing and future conditions.

Basin	**Area (acres)**	
	Existing	**Future**
Sub Basin 1	702	502
Sub Basin 2	493	493
Sub Basin 3	717	717
Sub Basin 4	574	416
Sub Basin 5	727	673
Sub Basin 6	116	110
Sub Basin 10	-	200
Sub Basin 11	-	136
Sub Basin 15	-	29
Rosecrest/South Hills 1*	-	64
Rosecrest/South Hills 2*	-	11
Mountain View Corridor North**	-	127
Mountain View Corridor South**	-	78
Provo-Reservoir	18	16
Power Plant	13	13
Parry Farms	68	68
TOTAL	3,427	3,651

*The extents and area of these basins are based on the data shown in the "Rosecrest & South Hills Development Storm Drain Master Plan" produced by NOLTE Associates, Inc.

**The extents and area of these basins are based on the data provided by UDOT.

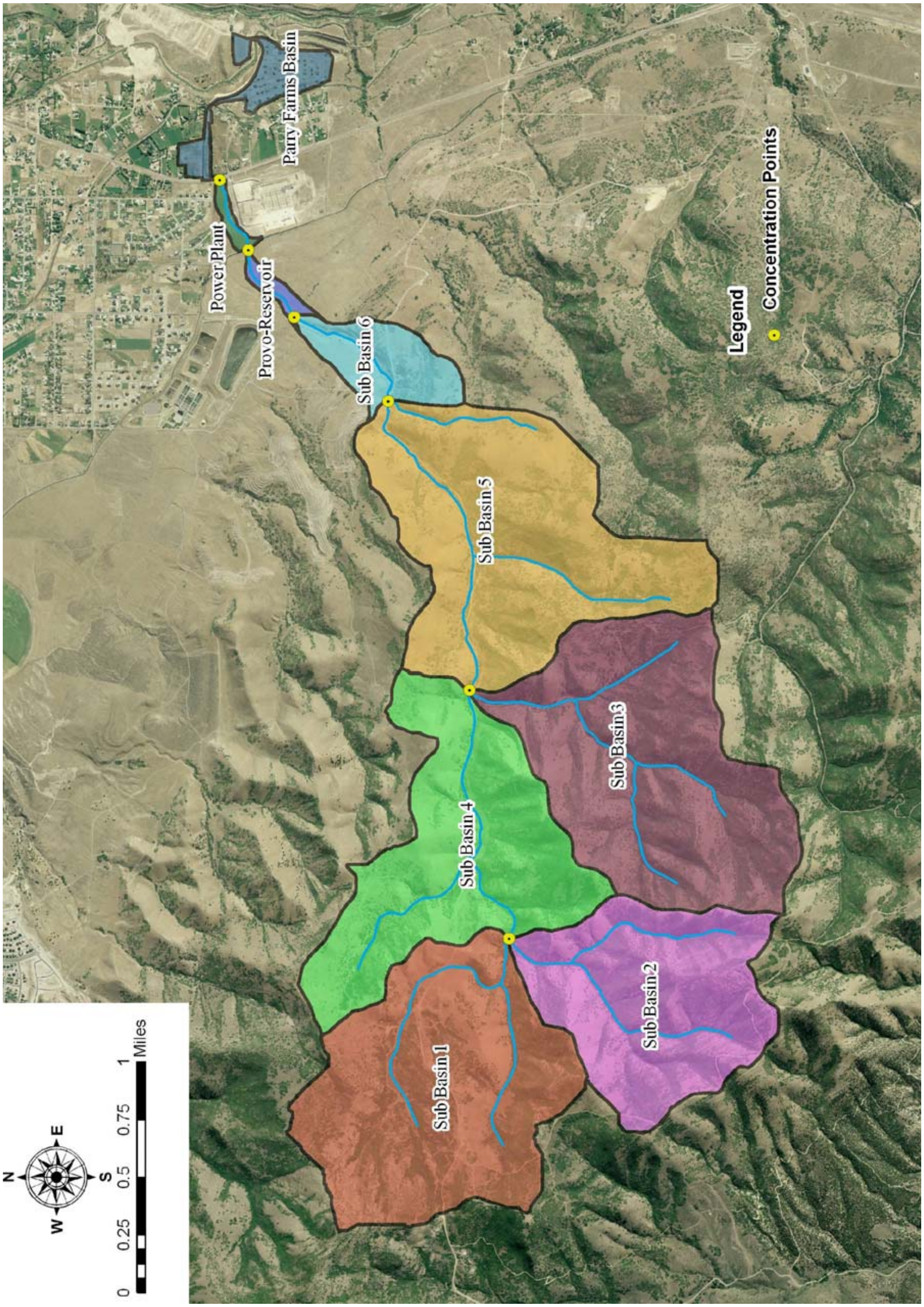

Figure 12. Sub-basin delineation for existing conditions.

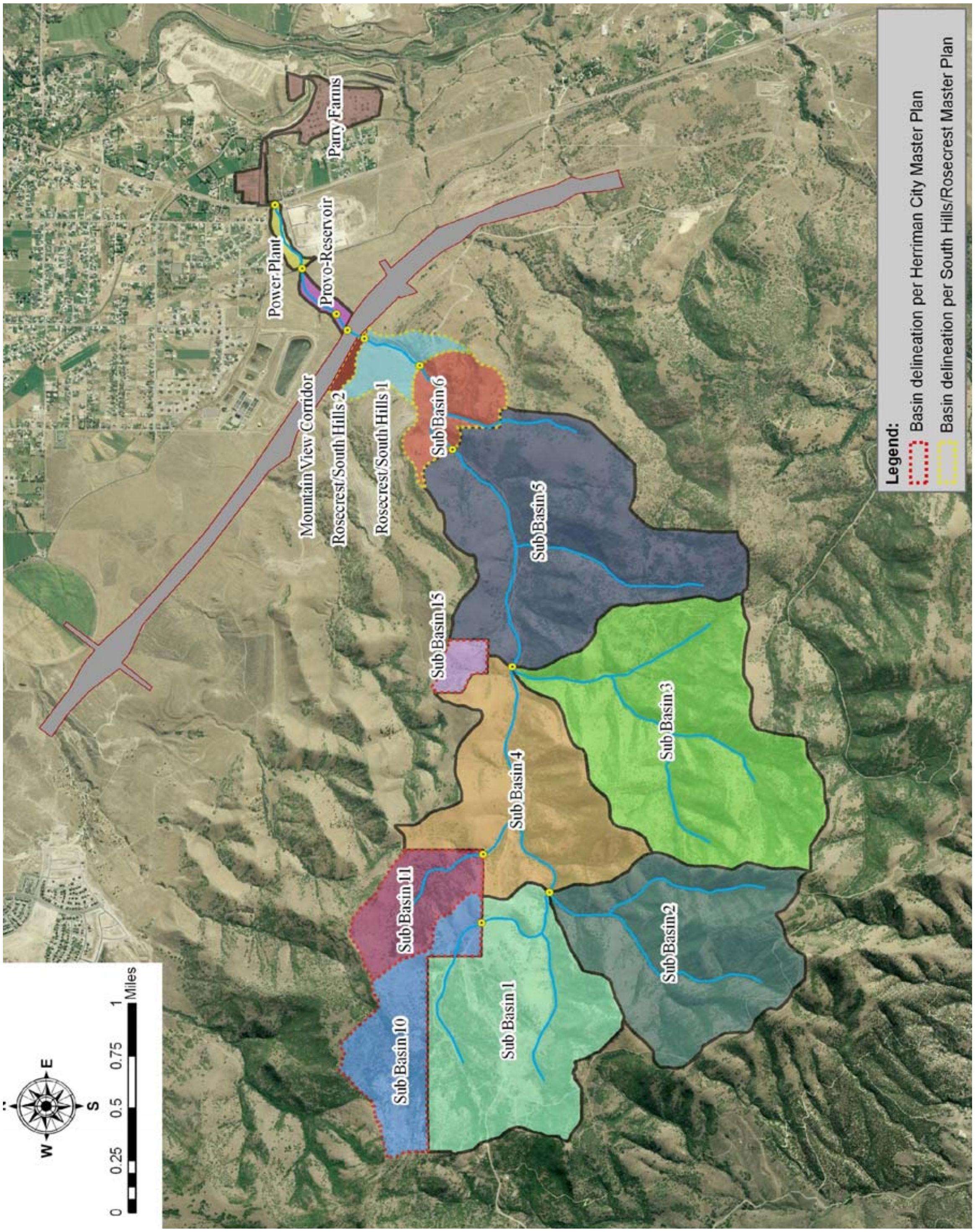

Figure 13. Sub-basin delineation for future conditions.

3.1.6 Land Use/Land Cover

In order to assess existing, and future land use/land cover, a variety of data was collected and used from the following sources:

- A nationwide USGS study of land use/land cover was completed in 2001. This study provided information on tree/vegetation canopy, impervious areas, and general land use/land cover. Tree canopy data (along with aerial photography and site visits) was useful to help establish vegetative cover per SCS methods and for estimating soil infiltration.
- Aerial photography. A 2006 color aerial photography from the National Agricultural Imagery Program (NAIP) provided at 1-meter resolution was helpful in assessing existing conditions relative to land use/land cover.
- Geographic Information System (GIS) data layers provided by the State of Utah Automated Geographic Reference Center (AGRC) and the Environmental Protection Agency (EPA) representing dominant vegetation as well as agricultural/urban land use were also used.
- Land use descriptions used in previous drainage studies in the area.
- Field observations and site visits.
- Zoning/Land use information provided by the associated municipalities.
- Contacts with Camp Williams
- Nolte Associates, Inc, "Rosecrest & South Hills Development-Storm Drain Master Plan", November, 2006.

Existing Conditions

Currently, the majority of the watershed is undeveloped. Field observations, collected data, and previous studies indicate that much of the undeveloped area is dominated by Oak-Aspen and Herbaceous complexes containing oak brush, aspen, mountain mahogany, bitter brush, maple, grass mixtures, weeds, and other types of low-growing brushes, shrub, and scrub rangeland. The Parry Farms area of the watershed is typical of a medium-density residential development with an average ½-acre lot size. Following a careful evaluation of each data source, the land use and land cover dataset for use in the existing conditions analysis was developed, assigned and coded to comparable categories listed in the TR-55 manual for Curve Numbers. Land use is shown in Figure 14.

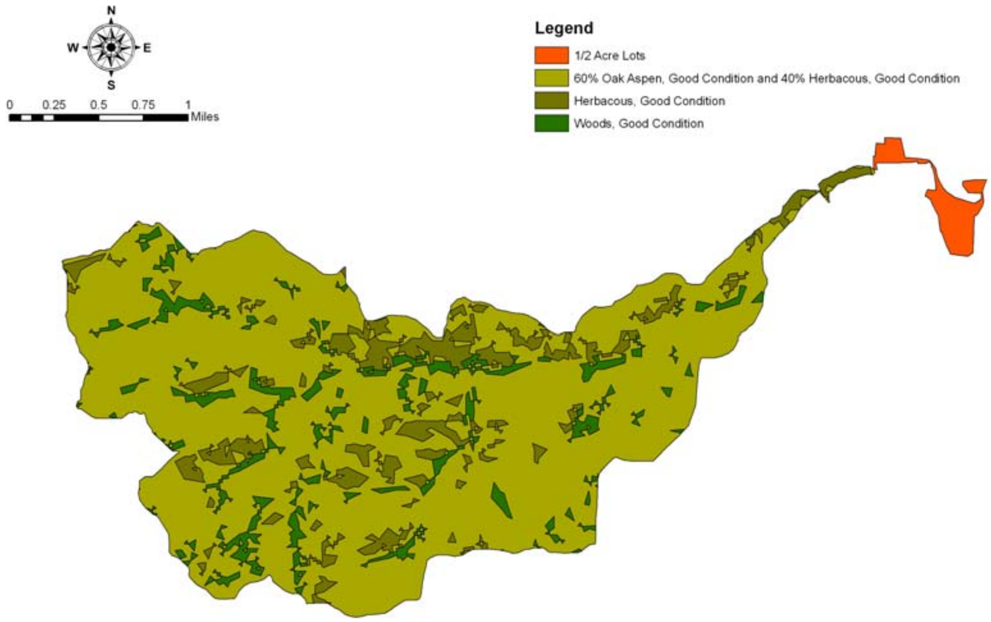

Figure 14. Existing land use and land cover classifications used for this study.

Future Conditions

This portion of the Salt Lake County is expected to eventually transition from the undisturbed and rural setting to a more developed urban area. As such, it is expected that the major hydrologic characteristics of the drainage basin will be impacted. In order to estimate future land use patterns several sources were used:

- Bluffdale City Zoning Maps
- Herriman City Zoning Maps
- Nolte Associates, Inc, Rosecrest & South Hills Development-Storm Drain Master Plan", November, 2006.
- Salt Lake County GIS data containing land use projections for the entire county.
- Coordination with Herriman City, Bluffdale City, Salt Lake County, UDOT, and Camp Williams personnel.

In some cases, the data presented in these sources was contradictory. In these cases, the land use which would, theoretically, produce a larger runoff was used in the model. Such a conservative approach was requested by the Salt Lake County Engineering Division.

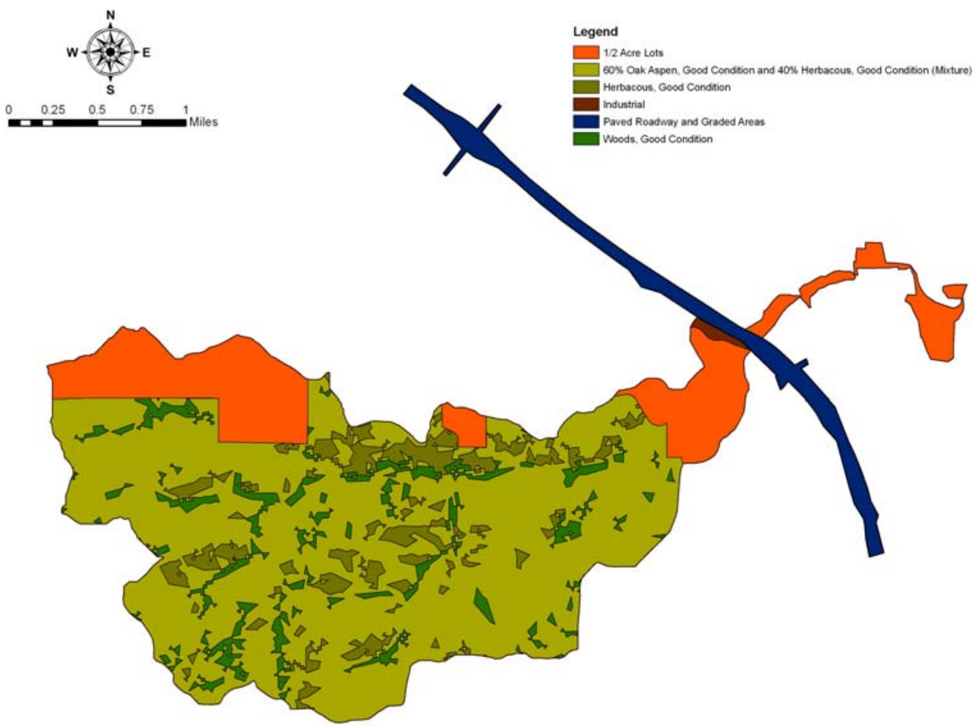

Figure 15. Future land use patterns used for this study.

3.1.7 Soil Type

Areas in and around the watershed have been surveyed and classified in past years by the Soil Conservation Service (SCS), now known as the Natural Resources Conservation Service (NRCS). For hydrologic purposes, soils are typically classified into groups A, B, C, or D. These Hydrologic Soil Groups (HSG) are based on the rate at which the soil is able to absorb moisture and precipitation.

In general, Group A soils have low runoff potential and high infiltration rates (over 0.3 inches/hour) even when wet, and typically consist of sands, gravels, and some loams. In contrast and on the other end of the spectrum, Group D soils have the highest runoff potential due to low infiltration rates (less than 0.05 inches/hour), and consist of high swelling clays and other impermeable materials.

Soils data in GIS format are readily available from a variety of agencies. Soil series and mapping unit data was ultimately provided by the NRCS. In addition to the State AGRC, the NRCS Data Gateway and Soils Data Mart were used to provide and verify the information.

Figure 16 illustrates the extent of these soils groups over the historic watershed boundary. It can be seen that predominantly clay-type "D" soils exist on the upper reaches of the watershed. The less permeable "C" soils are predominant in the lower reaches of the watershed, with the "B" type soils dominating the areas around the Provo-Reservoir canal and Camp Williams Road.

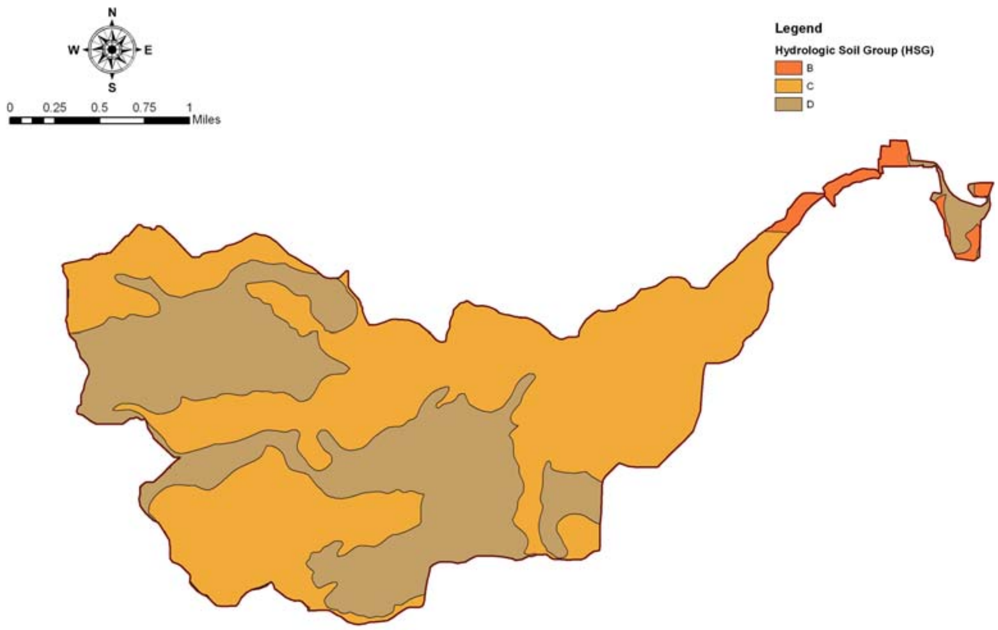

Figure 16. HSGs illustrated in the existing Wood Hollow watershed.

3.1.8 Infiltration Losses and Abstractions

Losses due to soil infiltration are an important part of the precipitation-runoff cycle. During a storm event, a portion of the precipitation is "lost" as it infiltrates into the ground. This rainfall fraction does not become surface runoff, and is also referred to as rainfall excess or effective rainfall. The SCS Curve Number (CN) model was used in HEC-HMS to assess losses due to infiltration. This method is one of the most common and standard methods used today. CN values for each unique combination of soil type and land use were carefully selected from published literature (USDA TR-55). These CN values correspond to Antecedent Runoff Condition II (ARC, formerly known as Antecedent Moisture Condition, or AMC), and represents average moisture conditions prior to a storm event taking place.

An area-weighted average of CN values was then computed by GIS and for each sub-basin, yielding a Composite Curve Number (CCN) to be used in the HEC-HMS model. CN values published in TR-55 were used for each distinct combination of land use/land cover and HSG. The resulting CCN's are listed in Table 6. Due to the changes in the land use characteristics, some CCN's have changed from the existing to future conditions.

Table 6. CCN values for the Wood Hollow watershed.

Basin	Composite Curve Number (CCN)	
	Existing	**Future**
Sub Basin 1	62	63
Sub Basin 2	60	60
Sub Basin 3	64	64
Sub Basin 4	61	62
Sub Basin 5	57	58
Sub Basin 6	56	80
Sub Basin 10	-	81
Sub Basin 11	-	82
Sub Basin 15	-	80
Rosecrest/South Hills 1	-	80
Rosecrest/South Hills 2	-	91
Mountain View Corridor North*	-	84
Mountain View Corridor South*	-	84
Provo-Reservoir	55	70
Power Plant	59	70
Parry Farms	78	78

*Based on the data provided by UDOT.

3.1.9 Precipitation and Rainfall

Design Storm Duration and Frequency

Storms with longer durations, lower intensity, and relatively large runoff volumes (e.g., 100-year 24-hour) are commonly used in models and hydrology studies, especially when a retention/detention basin or other type of impoundment is to be sized. Storms and cloud bursts with higher intensity but shorter duration and less runoff volume (e.g., 100-year 6-hour) are commonly used to design conveyance facilities such as culverts, pipelines, and open channels.

For this study, several storm durations of 1, 3, 6, 12, and 24 hours were used. This allowed an evaluation of both higher and lower-intensity events, respectively. Peak discharge rates were assessed for 100-year storm events. Therefore, a total of five different storm events were modeled, each having a combination of recurrence interval and storm duration (e.g., 100-year 6-hour storm).

The design storm precipitation depths were obtained from the "Rainfall Intensity Duration Analysis, Salt Lake County, Utah" prepared for the Salt Lake County by TRC North American Weather Consultants (1999). Because precipitation depth isohyets included in this study do not extend fully into the area of interest, extrapolation was used to estimate the precipitation depth values from the shown isohyets. Consequently, the precipitation depths listed in Table 7 have been used to develop the different design storms.

Table 7. Precipitation depth values used in the model.

Return Period/Duration	Precipitation Depth (inches)
100 Year, 1-Hour	1.50
100 Year, 3-Hour	1.80
100 Year, 6-Hour	2.00
100 Year, 12-Hour	2.50
100 Year, 24-Hour	2.75

Due to the relatively small size of the watershed, depth-area reductions were not used.

Temporal Distribution

The time-distribution of the rainfall amount can be a sensitive factor in the precipitation-runoff response. Cumulative mass curves represent a rainfall hyetograph, or intensity over time. For this study, two different temporal distributions were used. For the events with durations of 6 hours or less, the Farmer-Fletcher 2nd quartile distribution was used. For the longer duration (12 and 24-hour) events, the Great Basin Experimental Area (GBEA) distribution 3rd quartile curves were used. The GBEA distribution is derived from the same data as the Farmer-Fletcher temporal distribution and is considered to be more appropriate for longer event durations (between 6 and 24 hours). For the same reason, the Farmer-Fletcher distribution is more suitable for storm durations of less than 6 hours. Examples of these curves are shown in Figure 17. The tabular view of these curves is included in Appendix C.

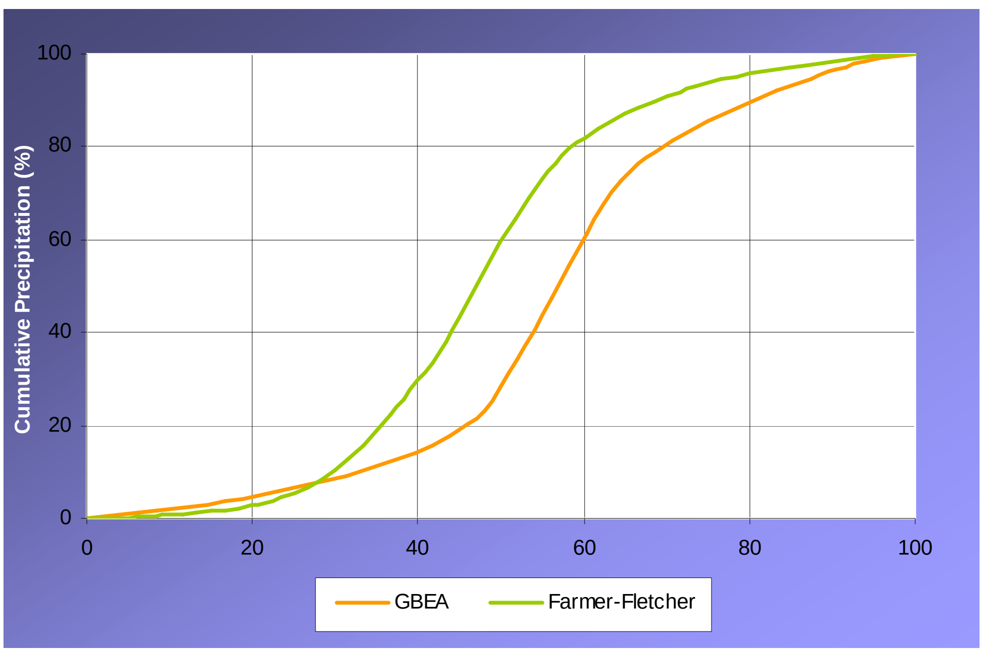

Figure 17. Temporal distribution comparison.

3.1.10 Transform Method

Without gaged storm-response data from this particular watershed, a synthetic method of transforming runoff to a time-based hydrograph was used. The SCS Dimensionless Unit Hydrograph method is a common method supported by the model used for this study. This particular method uses a Peak Attenuation Factor (also called a Peak Rate Factor), K, to dictate the shape and peak of the synthetic unit hydrograph. A typical SCS K value of 484 is hard-coded into HEC-HMS due to its broad applicability resulting from several watershed studies.

3.1.11 Basin Lag Time

The basin lag time for mountain areas was calculated using the regression equation outlined in the study entitled "Lag Time Characteristics for Small Watersheds in the US" by M.J.Simas and R.H. Hawkins. The equation uses the basin area, slope, and curve number.

$$\mathbf{T_{lag} = 0.0051 \times Width^{(0.594)} \times Slope^{(-0.15)} \times S_{nat}^{(0.313)}}$$

where

Width = Watershed Area (sq.ft)/Watershed Length (ft)

Slope = Maximum Elevation Difference (ft)/Longest Flow Path (ft)

S_{nat} = 1000/CN – 10

Table 8 shows the computed lag times for the existing and future conditions.

Table 8. Lag times for the Wood Hollow watershed.

Basin	Lag Time, t_L (minutes)	
	Existing	**Future**
Sub Basin 1	88	79
Sub Basin 2	82	82
Sub Basin 3	83	83
Sub Basin 4	84	72
Sub Basin 5	90	85
Sub Basin 6	51	47
Sub Basin 10	-	38
Sub Basin 11	-	38
Sub Basin 15	-	31
Rosecrest/South Hills 1	-	49
Rosecrest/South Hills 2	-	13
Mountain View Corridor North*	-	40
Mountain View Corridor South*	-	25
Provo-Reservoir	26	29
Power Plant	26	26
Parry Farms	26	26

* Values obtained from UDOT.

3.1.12 Routing

The Muskingam-Cunge method of river reach routing was used to route flow hydrographs from one concentration point to another. This is an appropriate method for the range of slopes encountered in this area. The channel geometry, slope, and roughness was obtained from the given topography data and from field observations. The data for the reaches of pipe flow was obtained from the Stantec's "Parry Farms Phase I-Storm Drainage Pipe and Pond Calculations" and from the "Rosecrest and South Hills Development Storm drain Master Plan where applicable.

Table 9. Reach routing parameters used in the HEC-HMS model.

	Reach Parameters				
	Reach	Length (ft)	Slope (ft/ft)	Manning's n	Shape
Existing Sub-Basins	Reach 1	6,436	0.0486	0.04	Irregular Section
	Reach 2	7,602	0.0446	0.04	Irregular Section
	Reach 3	3,273	0.0425	0.04	Irregular Section
	Reach 4	1,981	0.0474	0.04	Irregular Section
	Reach 5	1,849	0.0433	0.04	Irregular Section
	Reach 6	1,571	0.029	0.012	36" RCP
	Reach 7	524	0.076	0.012	36" RCP
	Reach 8	1,509	0.0266	0.012	48" RCP
	Reach 9	886	0.0407	0.012	48" RCP
Future Sub-Basins	Reach 1	2,560	0.046	0.04	Irregular Section
	Reach 2	6,221	0.046	0.04	Irregular Section
	Reach 3	2,583	0.0406	0.04	Irregular Section
	Reach 4	1,536	0.043	0.04	Irregular Section
	Reach 5	1,849	0.043	0.04	Irregular Section
	Reach 6	1,571	0.029	0.012	36" RCP
	Reach 7	524	0.076	0.012	36" RCP
	Reach 8	1,509	0.0266	0.012	48" RCP
	Reach 9	886	0.0407	0.012	48" RCP
	Reach 10	1,563	0.048	0.04	Irregular Section
	Reach 11	466	0.028	0.04	Irregular Section
	Reach 12	487	0.057	0.04	Irregular Section
	Reach 13	1,737	0.045	0.04	Irregular Section
	Reach 14	1,417	0.042	0.04	Irregular Section
	Reach 15	3,876	0.051	0.04	Irregular Section
	Reach 16	708	0.085	0.04	Irregular Section
	Reach 17	178	0.1928	0.013	18" RCP

Routing flows through detention ponds modeled as part of this study was accomplished in HEC-HMS using the level-pool routing method (also known as the inventory, modified pulse, or storage indication method). A stage-storage-discharge relationship curve was developed for every detention pond based on the allowed discharge rate from the pond (See Appendix A for stage-storage-discharge data). It is assumed that this curve offers an adequate representation of future conditions.

3.1.13 Model Development

Ultimately, HEC-HMS v3.0.1, developed by the US Army Corps of Engineers (USACE), was used to numerically model the precipitation-runoff response for each storm event. This model is one of the most common and standard ways to assess the hydrology of drainage basins, especially for large-scale regional studies. HEC-HMS is the recent generation of the long-standing HEC-1 model which has been used by engineers for years to model surface water runoff. It was decided that this particular model was an appropriate selection for the purposes of this study. HEC-HMS is especially well suited for hydrograph synthesis and the hydraulic routing of storm flows through detention basins. Furthermore, the model is freely available to the public and relatively easy to update and maintain. The topologic tree for the existing conditions scenario is shown in Figure 18.

In order to assess future impacts, the future condition models represent impacts from development and changes in land use. This was represented in the model by a corresponding change in CCN value and/or additional impervious areas. Other parameters such as sub-basin area/boundary, routing, and travel times were adjusted accordingly if the available information warranted this. In accordance with instructions from the Salt Lake County, it was assumed that the runoff generated from all new development within the study area would be detained to a prescriptive amount.

In order to achieve this, the future conditions model includes several "dummy" detention ponds that serve this purpose. Based on the results of the existing conditions model it was determined that the overall watershed produces somewhere between 0.04 and 0.05 cfs/acre of runoff for the different storm events. Consequently, the 0.05 cfs/acre discharge rate was used to develop the stage-storage-discharge curves for the detention ponds. Also, the detention ponds were sized to detain the critical event flows.

Therefore, the model representing future conditions is a "mitigated" scenario that addresses the impacts of future development. However, drainage from the Mountain View Corridor is not detained in this analysis, but rather, is modeled as a direct discharge (undetained) to Wood Hollow. Therefore, a noted exception to the mitigated model is that any County and/or UDOT flood control facilities (e.g., ponds) that may be proposed in this area are not currently part of the future conditions model. Should additional facilities be necessary to help control or convey storm flows in this area, the information from this study and additional modeling/analysis will be used to assist in the planning and design effort. The topologic tree for the future conditions scenario is shown in Figure 19. Table 10 shows the summary of HEC-HMS input data.

Table 10. HEC-HMS model input data summary.

Basin	Area (acres)		CCN		Lag Time (min.)	
	Existing	Future	Existing	Future	Existing	Future
Sub Basin 1	702	502	62	63	88	79
Sub Basin 2	493	493	60	60	82	82
Sub Basin 3	717	717	64	64	83	83
Sub Basin 4	574	416	61	62	84	72
Sub Basin 5	727	673	57	58	90	85
Sub Basin 6	116	110	56	80	51	47
Sub Basin 10	-	200	-	81	-	38
Sub Basin 11	-	136	-	82	-	38
Sub Basin 15	-	29	-	80	-	31
Rosecrest/South Hills 1	-	64	-	80	-	49
Rosecrest/South Hills 2	-	11	-	91	-	13
Mountain View Corridor North	-	127	-	84	-	40
Mountain View Corridor South	-	78	-	84	-	25
Provo-Reservoir	18	16	55	70	26	29
Power Plant	13	13	59	70	26	26
Parry Farms	68	68	78	78	26	26

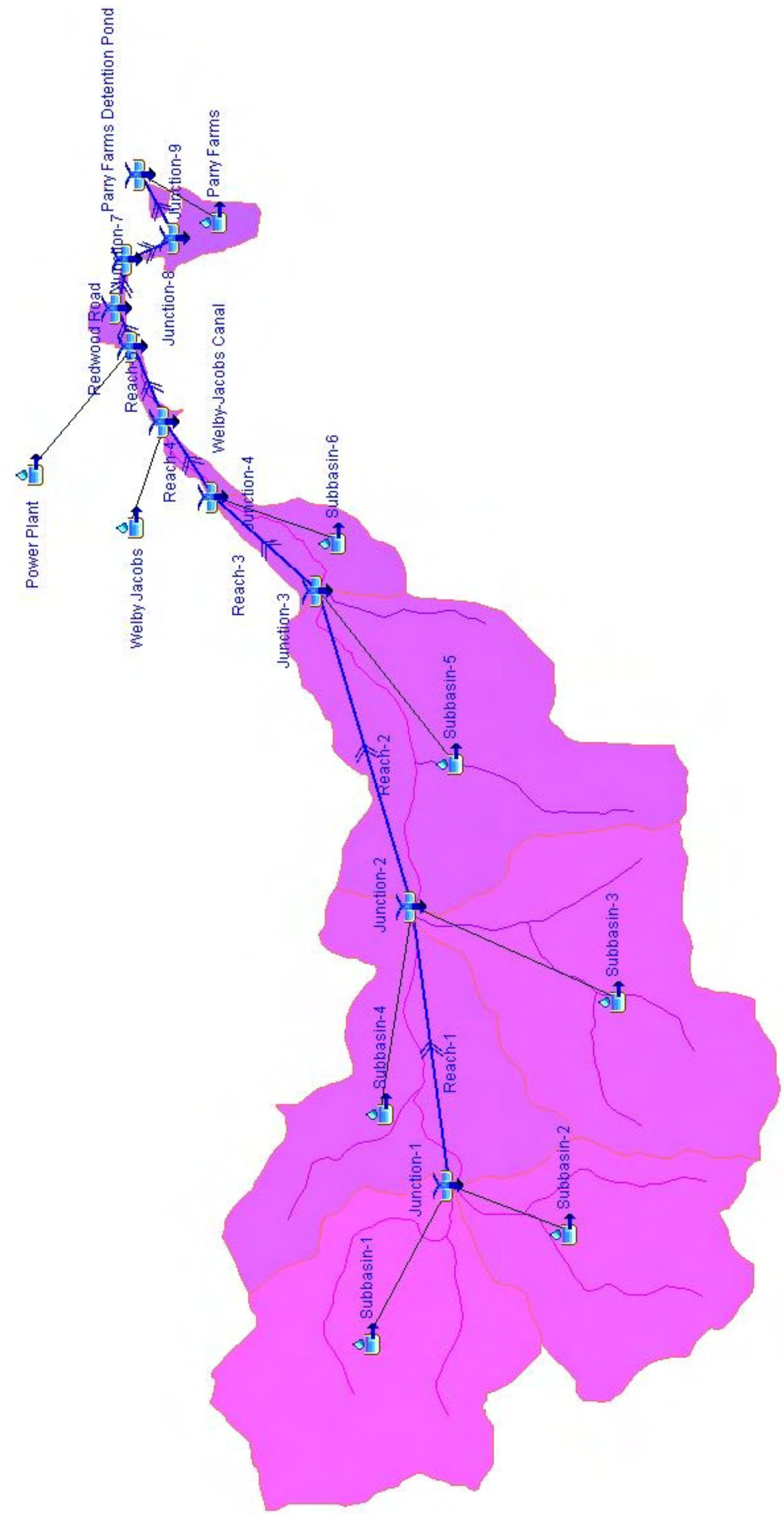

Figure 18. Topologic tree used in HEC-HMS for historic conditions.

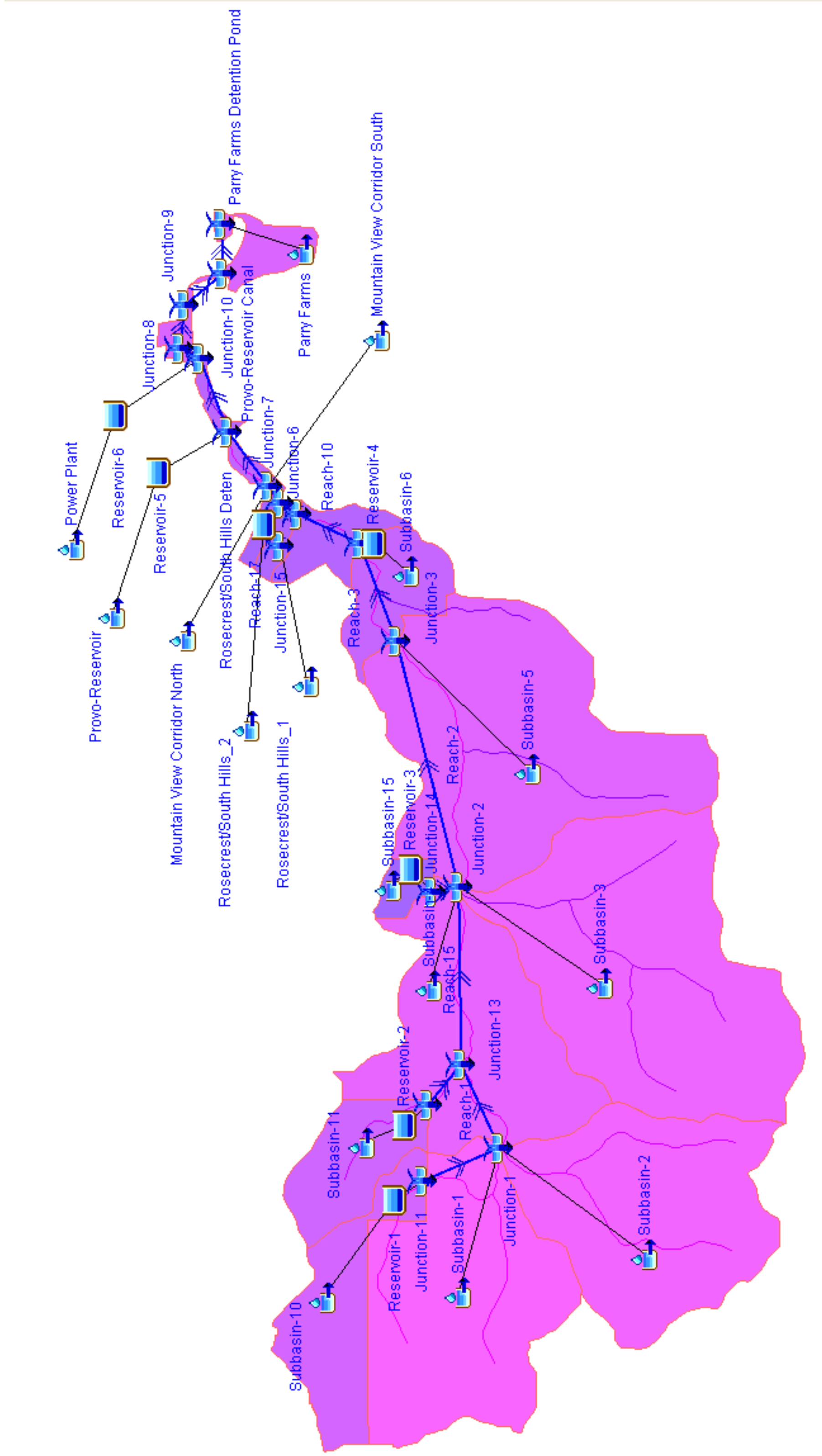

Figure 19. Topologic tree used in HEC-HMS for future conditions.

3.2 Hydrologic Results

3.2.1 Peak Discharge and Runoff Volume

Peak discharge values and runoff volumes were obtained from the model at the critical locations and are listed in Table 11 and Table 12 respectively. The highest peak discharge is produced during the 100-year 12-hour event for both the existing and future scenarios. Based on the computed results an average cfs/acre runoff production value of 0.05 is extracted.

Table 11. Peak discharge values at selected locations.

Location	100 Year Peak Discharge Q (cfs)									
	Existing					Future				
	1-Hour	3-Hour	6-Hour	12-Hour	24-Hour	1-Hour	3-Hour	6-Hour	12-Hour	24-Hour
Provo-Reservoir Canal	16	68	85	140	126	96	141	99	173	155
Redwood Road	16	68	85	141	126	96	141	99	174	155
Parry Farms Detention Pond	24	68	88	147	132	115	172	105	178	160

Table 12. Runoff volume values at selected locations.

Location	100 Year Runoff Volume (ac-ft)									
	Existing					Future				
	1-Hour	3-Hour	6-Hour	12-Hour	24-Hour	1-Hour	3-Hour	6-Hour	12-Hour	24-Hour
Provo-Reservoir Canal	3	11	20	54	75	25	44	61	112	142
Redwood Road	3	11	20	54	76	25	44	61	112	143
Parry Farms Detention Pond	4	13	23	58	81	27	47	64	117	149

The following figure illustrates the resulting hydrographs for the 100-year 12-hour event for future conditions at key locations.

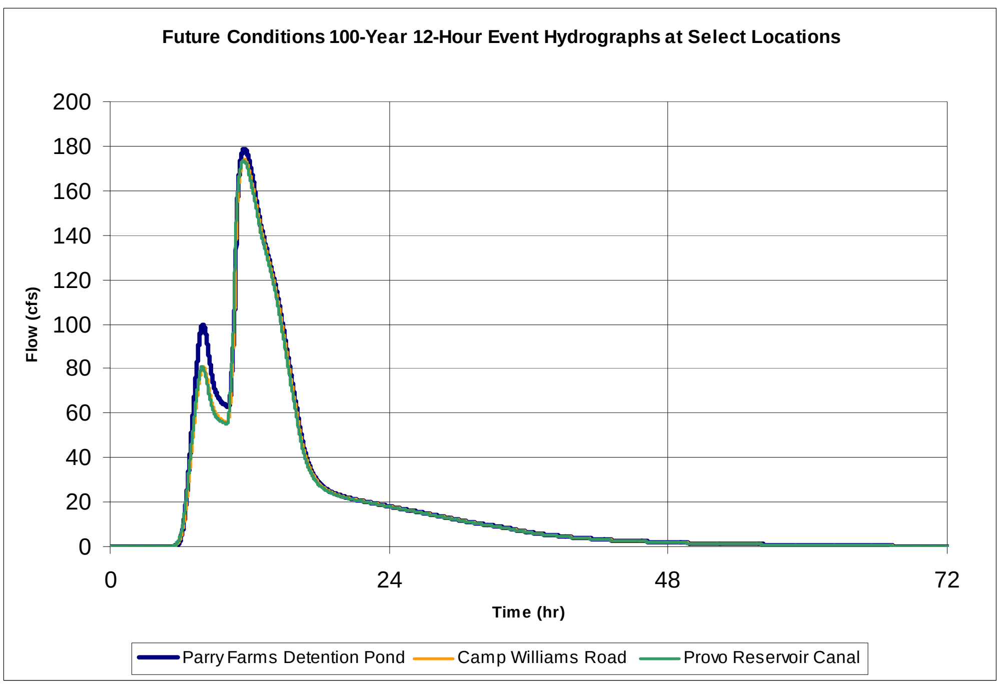

Figure 20. Resulting hydrographs at select locations of interest.

3.2.2 Calibration and Comparison to Other Studies

In an effort to better substantiate model results, a comparison to other studies performed in the general area was performed. These included some of the studies referenced earlier in this report. Some of these studies used methods similar or comparable to those used in this report (e.g., SCS/NRCS methods). The summary of the existing peak values obtained for the Provo-Reservoir Canal location is given in Table 13.

Table 13. Study comparison for existing peak discharge at the Provo-Reservoir Canal.

Study	Existing Peak Discharge (cfs)
NFF	153
2002 BC&A Study	115
Psomas	140

Regarding the NFF value listed in Table 13, it is noted that storm duration is not always relevant. Regression values such as those from National Flood Frequency Program (NFF) or Water Resources Investigation (WRI) 83-4129 can contain errors of 30 percent or much more in some cases (USGS NFF, USGS Water Supply Paper, Haestad 5.4, USGS WRI). Also, the flows reported in the BC&A study are for the 3-hour event which is not the critical duration for this particular study. The peak discharges for the 3-hour duration obtained with this study at the Provo-Reservoir Canal are 68 and 141 cfs for the existing and future conditions respectively.

3.3 Hydrologic Conclusions & Recommendations

The results obtained from this study are consistent with the BC&A study and the regional regression NFF equations. As such, it is noted that the often-encountered 0.2 cfs/acre discharge restriction is considerably higher than what the land in this area appears to produce in terms of 100-year runoff values. It is recommended that the peak discharge values obtained using the future conditions scenario should be used for future planning and design efforts. It is also recommended that any future developments, within the Wood Hollow watershed, consider the results of this study and understand the approach and assumptions made in this study.

Section 4 - Facility Inventory

4.1 Introduction

This section presents an inventory of existing drainage and flood control facilities within the Wood Hollow drainage. The inventory includes a physical description, estimated hydraulic capacity, and a map depicting identified facility location.

4.2 Sources of Data

The following sources were used in preparing the Wood Hollow facility inventory:

- As-built drawings for Parry Farms development provided by the Salt Lake County
- Field survey of existing drainage profile and selected cross sections, 2008
- Site visits and filed inspections of channel and culvert conditions, 2007 and 2008

4.3 Overview of Existing Drainage Conditions

For the purpose of this study, the Wood Hollow Drainage is divided in four areas listed below and shown in Figure 21.

- Lower Wood Hollow
- Treatment Plant Area
- Power Station Area
- Iron Horse Boulevard

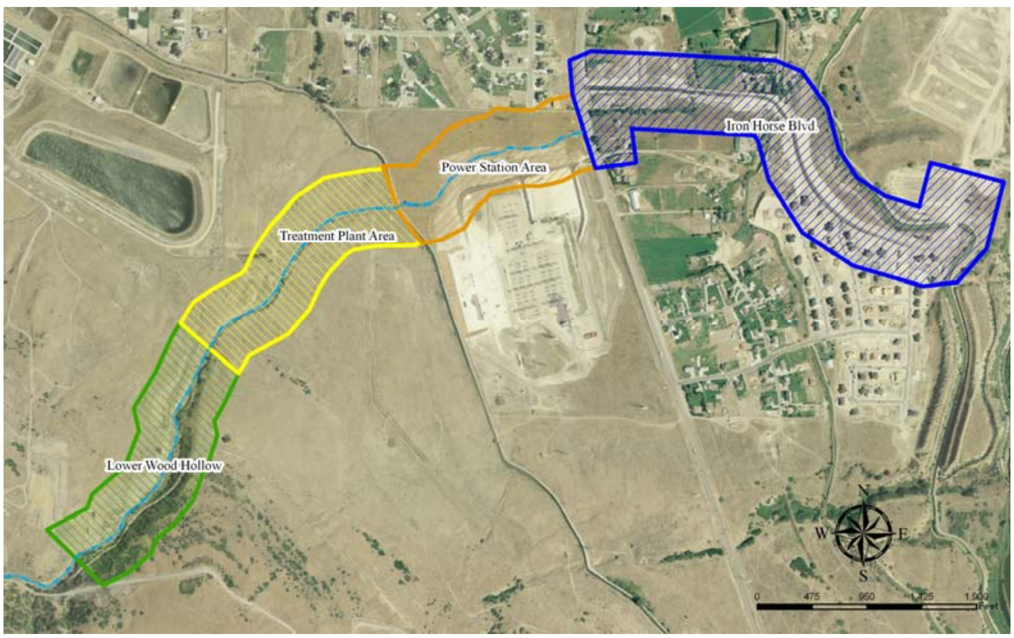

Figure 21. Wood Hollow Study Areas

4.3.1 Lower Wood Hollow

Lower Wood Hollow Area is a relatively undisturbed portion of the Wood Hollow Drainage. This section is characterized by a large natural drainage channel with depths ranging from six to 30 feet deep and 100 to 300 feet wide as shown in Figure 22. The northeastern boundary of this drainage area is defined by a service road crossing the drainage channel as shown in Figure 23. Field inspection did not identify any functioning conveyance structures (culverts or bridges) which would allow the Wood Hollow flows to pass under the road. From observations it is concluded that the flows are overtopping this road as they are conveyed downstream.

Figure 22. Lower Wood Hollow natural drainage channel

Figure 23. Service road blockage of Wood Hollow's natural drainage channel

4.3.2 Treatment Plant Area

This section is also a natural open channel drainage. Similar to the Upper Wood Hollow area, a service road crosses the drainage path with no evidence of any conveyance structures passing the Wood Hollow flows. The natural channel upstream and downstream of this crossing is relatively well-defined. This area terminates at the Wood Hollow crossing of the Provo-Reservoir canal. At this location, a 40-inch steel pipe is installed for the apparent purpose of conveying substantial Wood Hollow flows across the canal (Figure 24). The conditions observed at the pipe inlet indicate that very little of the Wood Hollow flows are actually conveyed across the canal through this pipe, and are most likely intercepted by the Provo-Reservoir canal.

Figure 24. Looking upstream of the steel pipe crossing over the Provo-Reservoir canal

4.3.3 Power Station Area

Downstream of the Provo-Reservoir Canal the characteristics of the Wood Hollow drainage change significantly. The natural channel continues for a short distance where it is intercepted by a man-made triangular diversion channel, as shown below in Figure 25, constructed by PacifiCorp. The channel depth varies from three to six feet and 20 to 35 feet wide. Several check dams constructed from large boulders were observed in the lower portions of this channel. The channel terminates in a relatively flat area along the west side of Camp Williams Road. During the site visits, a culvert inlet was observed at this location but no outlet was found on the east side of the road. It was concluded that no Wood Hollow flows have crossed the Camp Williams Road for an extended period of time. Currently a 42-inch culvert is being constructed under Camp Williams Road; however, it is intentionally blocked to prevent Wood Hollow flows from passing through until it is determined that downstream facilities and stakeholders will not be adversely affected.

Figure 25. Man-made triangular channel in power station area, looking upstream

4.3.4 Iron Horse Blvd. Storm Drain System

The Iron Horse Blvd. storm drain system is located on the east side of Camp Williams Road. The original intent of the storm drain system was to accommodate tributary urbanized runoff and Wood Hollow flows. The storm drain system consists of catch basins, pipes, a detention pond, and an outfall pipe line to Jordan River. Currently no connection exists which would allow any Wood Hollow flows to enter the Iron Horse Blvd. storm drain system. The detention pond, which was built as a part of this system, was damaged (as shown below in Figure 26 taken during a site visit at the end of November 2007). Improvements such as re-grading of the basin and fore-bay, riprap armoring, and basin vegetation lining have been made since the November 2007 site visit.

Figure 26. Parry Farms detention basin November 2007

4.4 Inventory of Existing Facilities

The existing facilities and locations of interest are listed below and shown in Exhibit 1.

1. Service road crossing #1
2. Service road crossing #2
3. Provo-Reservoir Canal crossing
4. Open channel in the power station area
5. Camp Williams Road crossing
6. Iron Horse Boulevard
7. Parry Farms Detention Pond

4.4.1 Existing Facility Capacity Assessment

The current capacity of the existing facilities was determined, whenever possible, using as-built information or design plans. Capacities were calculated using the following procedures.

Natural Channel Upstream of Provo Reservoir Canal

As shown in Figure 3 and Figure 22, the Wood Hollow drainage channel is very defined and large. The capacity of this natural drainage channel was computed using the Manning's formula/normal depth approach. Because this is a natural channel, no as-built information was available; therefore, the channel was surveyed at various cross sections. To be conservative, the channel sections with the mildest slope were used for the computation. The Manning's coefficient was estimated from observations made during the site visits. The capacity calculations for this channel are found in Appendix D.

- Natural channel upstream of Provo-Reservoir Canal capacity = 890 cfs

Steel Pipe Over Provo Reservoir Canal

Based on the topographical data provided by the county, the channel at the head of the steep pipe can only develop a maximum 1.31 foot depth. Assuming that there is no tailwater (free outfall), the maximum conveyance capacity of the 40-inch diameter steel pipe is approximately 20 cfs.

- Steel pipe over Provo-Reservoir Canal capacity = 20 cfs

Open Channel Downstream in the Power Station Area

Like the natural channel upstream of the Provo-Reservoir Canal, no as-built information was available, therefore a topographic survey of representative channel cross sections were used to determine the geometry of the entire channel downstream of the Provo-Reservoir Canal crossing.

A HEC-RAS model and free-board considerations were used to provide the hydraulic analysis and capacity of this channel. Due to the smaller size of this channel, the proximity to urban development, and the likely potential for Wood Hollow flows to be conveyed through this channel, a higher level of detail was involved with this analysis.

From the HEC-RAS model output, water surface elevations (including sequent depth) and velocities were used to determine the channel's required freeboard for any flow. Flows were increased in the model until the water surface or sequent depth level (for supercritical flow regime only) reached the channel's freeboard. The highest achieved flow without breaching the channel's freeboard is considered the channel's "safe" capacity. The "total" capacity was determined by assuming no freeboard. Freeboard was calculated as follows:

Equation 1. Freeboard

$$F_b = 0.5 + \frac{V^2}{2g}$$

Whereas:

F_b = Freeboard (ft)

V = Mean channel velocity (ft/s)

g = Gravitational acceleration (ft/s^2)

In order to ensure an adequate analysis, the HEC-RAS model was simulated under varying roughness values which range from n = 0.035 to 0.060. These calculations are found in Appendix E.

- Natural and improved channel's **safe** capacity = 4.9 cfs
- Natural and improved channel's **total** capacity = 30.9 cfs

Camp Williams Road Crossing

Currently a culvert is being constructed under Camp Williams Road; however, it is intentionally blocked to prevent Wood Hollow flows from passing through until it is determined that downstream facilities and stakeholders will not be adversely affected. As such, there is no current capacity through this facility, however it is understood that the proposed system is designed, by UDOT, to accommodate 80 cfs.

- Camp Williams Road crossing capacity = 80 cfs.

Iron Horse Boulevard

The Iron Horse Boulevard storm drain system was analyzed using available construction documents and StormCAD software. It was assumed that the system is at capacity when the Hydraulic Grade Line (HGL) does not exceed the existing ground elevation. A profile and summary of the tabular output of the system may be found in Appendix F. As shown in Figure 27, the storm drain system capacity increases substantially about halfway down Iron Horse Blvd at the inlet found at station 33+92.85 (per Stantec Construction Documents).

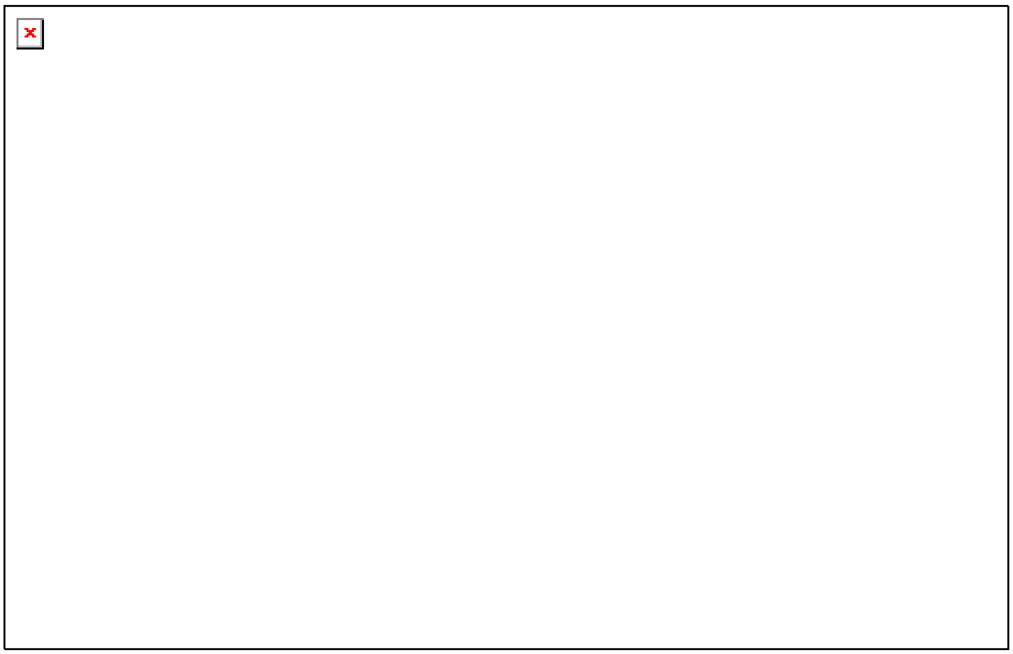

Figure 27. Iron Horse Blvd. storm drain system capacity

The capacities for the Iron Horse Boulevard Storm Drain (SD) system are:

- The limiting capacity of the overall system = 82 cfs
- The limiting capacity for the downstream half = 154 cfs

Section 5 - Alternative Development

5.1 Introduction

The purpose of this section is to propose adequate stormwater facility improvements using a descriptive alternative development process and comparison of each improvement alternative.

As shown in Table 11, the 100-year 12-hour future conditions peak discharge from Wood Hollow is estimated to be 173 cfs at the Provo Reservoir Canal crossing. Between the Provo-Reservoir Canal and the Parry Farms detention pond, there are no facilities that currently have capacity to convey these flows. Therefore, stormwater facility improvements must be considered in order for Wood Hollow runoff to be conveyed to the Jordan River.

5.2 Proposed Alignments

Generally, there are two main alignments that can be considered which are shown below in Figure 28. The only difference between the two alignments is that Alignment 1 considers utilizing the entire length Iron Horse Boulevard's public right-of-way, whereas Alignment 2 traverses parcels outside of the right-of-way in an effort to bypass the deficient portion of Iron Horse Boulevard's storm drain system.

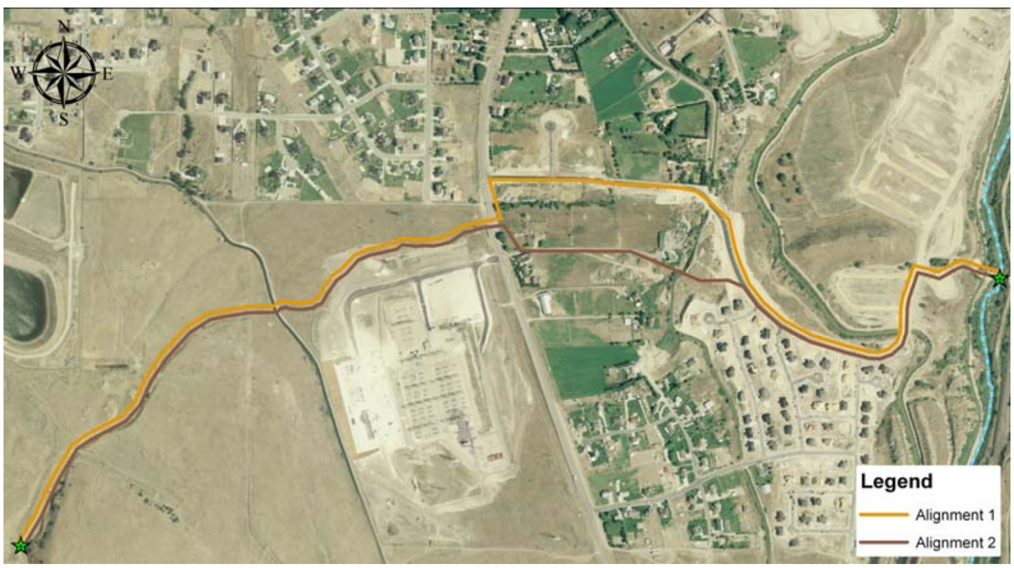

Figure 28. Two general alignments considered for project alternatives over 2006 aerial

As described more fully in later portions of this section, four alternatives are considered for this study. All of which are variations of the two main alignments illustrated above.

5.3 Imperative Improvements

Regardless of the preferred alternative, there are a number of common improvements that are proposed in each alternative, namely the abandonment of the existing service roads, construction of a regional detention facility, open channel improvements between the Provo Reservoir Canal and Camp Williams Road, Camp Williams Road crossing, and improvements to the Parry Farms detention pond.

5.3.1 Abandonment of Existing Service Roads

As shown in Exhibit 1, the two service roads (items one and two) prevent runoff conveyance from passing downstream. The service roads traverse and effectively act as dams in Wood Hollow's natural drainage path. Improvements will be required at the intersection of these two service roads.

The purpose of the service roads is not completely known. It is assumed that these roads have served the Jordan Valley Water Conservancy District (JVWCD). These service roads are expected to be abandoned with the construction of the proposed Herriman-Camp Williams Road based on meetings and discussions with the County, JVWCD, Bluffdale City and Herriman City.

5.3.2 Regional Detention

All four alternatives propose using at least a portion of the Iron Horse Boulevard storm drain system. As indicated earlier, this storm drain system has a capacity of 82 cfs thru 154 cfs depending on the location of the line. Therefore, because Wood Hollow's anticipated governing 100-year peak discharge is more than the capacities of the Iron Horse Boulevard storm drain system, restricting Wood Hollow flows upstream of the storm drain system will be required as part of each alternative's proposed improvements.

For alternatives that propose to use the entire length of the Iron Horse Blvd storm drain system, Wood Hollow peak discharge is required to restrict is flows by means of detention to less than 82 cfs. Likewise, for alternatives that propose to tie into the system downstream at station 33+92.85 (per Stantec construction documents), Wood Hollow peak discharge will be required to detain its flow to less than 154 cfs.

Regional Detention Pond Size

The detention facility has been sized through an iterative process by first arbitrarily choosing a footprint and depth. Afterwards, the associated stage-storage-discharge relationship curves were input into a time series based hydrologic software (HEC-HMS) to effectively model the anticipated Wood Hollow flows into the proposed detention facility. As expected, a pond that detains more flow yields a larger required pond size as shown below in Table 14. Therefore, alternatives which consider restricting flows to less than 82 cfs require a 38.6 ac-ft pond, and for the alternatives than consider restricting flows to less than 154 cfs require a 7.6 ac-ft pond.

Table 14. Anticipated Regional Detention Pond Size

Required Detention	Detention Pond Size (ac-ft)
To less than 82 cfs	38.6
To less than 154 cfs	7.6

Regional Detention Pond Location

The pond is strategically placed to reduce downstream improvement cost that will be required to convey unrestricted Wood Hollow drainage flows. As such, the pond is proposed to be located as far upstream as feasibly possible, without imposing its footprint on mountainside terrain. Therefore, the regional detention pond is proposed to be located immediately upstream of the Provo Reservoir Canal as shown below in Figure 29.

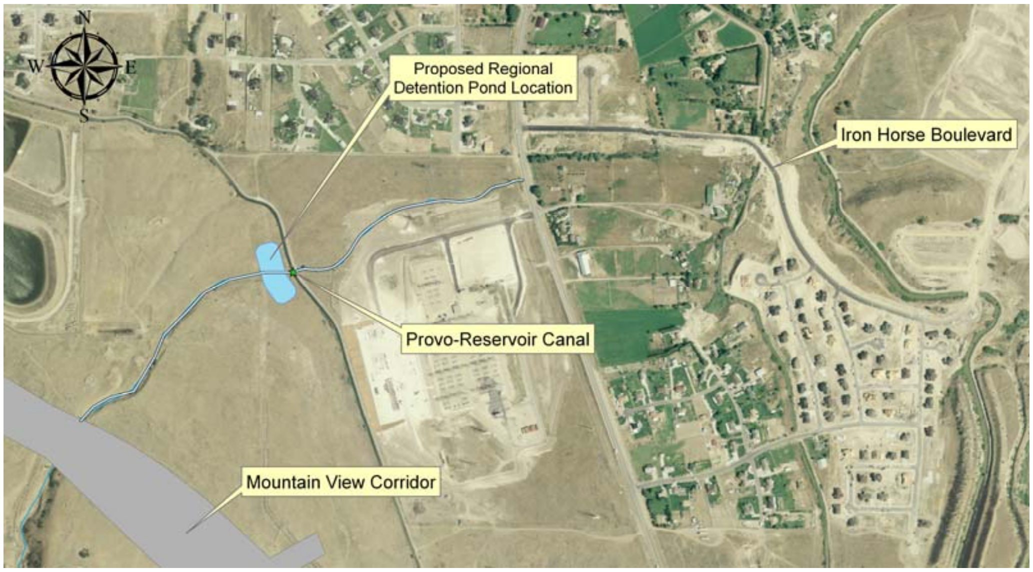

Figure 29. Regional detention pond over 2006 aerial

Proposed Corridor Effects on Regional Detention Pond

Utah Department of Transportation (UDOT) is developing a major transit corridor, called the Mountain View Corridor (MVC), shown above as the gray shaded area in Figure 29. UDOT proposes to manage its runoff such that approximately 205 acres of the corridor's surface area will drain off the corridor and easterly into the Wood Hollow drainage path. Therefore, runoff produced by the MVC was taken into consideration for sizing the proposed regional detention pond. Table 15 and Table 16 detail the MVC contributions to the proposed regional detention pond.

Table 15. Mountain View Corridor impacts to larger (38.6ac-ft) detention basin size

100-year 24-hour Event (Governing Storm Event)				
Parameter	With MVC	Without MVC	Difference	Difference
Drainage Area (acres)	3,651	3,446	205	5.9%
Peak Storage (acre-ft)	**38.6**	**31.2**	**7.4**	**23.7%**
Peak Inflow into Regional Detention (cfs)	155	139	19	13.3%
Runoff Volume at Regional Detention (acre-ft)	142	120.0	22.0	18.3%

Table 16. Mountain View Corridor impacts to smaller (7.6 ac-ft) detention pond

100-year 12-hour Event (Governing Storm Event)				
Parameter	With MVC	Without MVC	Difference	Difference
Drainage Area (acres)	3,651	3,446	205	5.9%
Peak Storage (acre-ft)	**7.6**	**6.5**	**1.1**	**16.9%**
Peak Inflow into Regional Detention (cfs)	172	154	19	12.0%
Runoff Volume at Regional Detention (acre-ft)	112	92.5	19.5	21.1%

Based on the information from the tables above, runoff contributions from the MVC require a 16.9% to 23.7% (depending on the preferred alternative) increase in detention pond size.

Therefore, it is recommended that the County consider negotiating cost participation with UDOT based on Table 15 and Table 16.

5.3.3 Open Channel Recommendations

The open channel between the Provo-Reservoir Canal and Camp Williams Road is not adequate to convey the peak flow for any 100 year storm event. As mentioned in Section 5, the existing total and safe capacity of this channel is 30.9 cfs and 4.9 cfs respectively.

5.3.4 Parry Farms Detention Facility

As shown in Figure 30, the existing Parry Farms detention facility is situated at the lower end of Iron Boulevard in such a way that it accepts all runoff from the Iron Horse storm drain system.

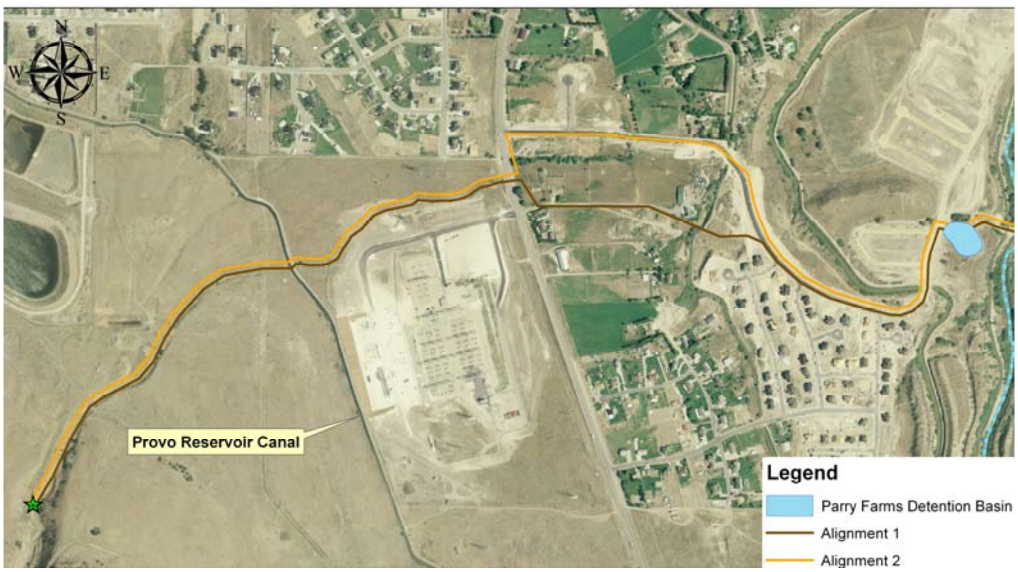

Figure 30. Parry Farms Detention Facility and Alternative Alignments over 2006 Aerial

As previously mentioned, Wood Hollow drainage has been altered in the areas east of the Provo-Reservoir Canal and little evidence exists that flows generated in the Wood Hollow drainage are conveyed to the historical outfall point at the Jordan River. Therefore it is anticipated that the Parry Farms detention facility is not adequately sized to handle runoff from Wood Hollow's watershed. As such, it is recommended for purposes of this study that the facility be evaluated and improved to safely accommodate Wood Hollow drainage.

5.4 Alternatives

Based on site investigation, various meetings and discussions with primary and secondary stakeholders, and Psomas' recommendation, there are four proposed alternatives in which runoff from Wood Hollow's watershed may be safely conveyed to its historic confluence with Jordan River.

5.4.1 Alternative 1

Aside from the imperative improvements mentioned above and in a general sense, Alternative 1 follows Alignment 1 and considers a 38.6 ac-ft regional detention pond and use of the entire length of Iron Horse Boulevard storm drain system with no improvements to the storm drain line (see Figure 31 below).

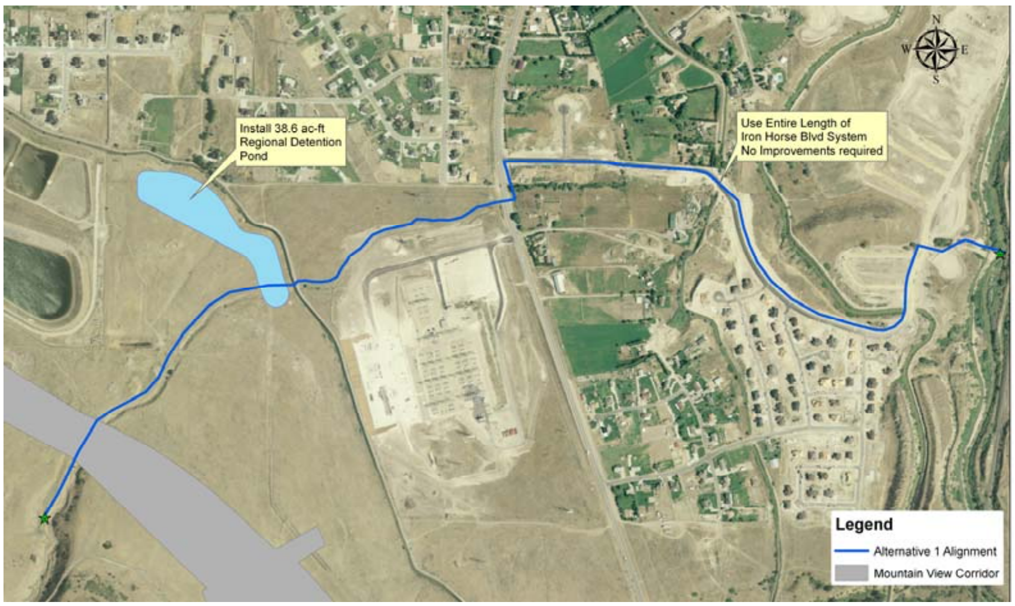

Figure 31. Alternative 1 Summary over 2006 aerial

As shown in Exhibit 2, this alternative consists of ten tasks as follows:

1. Remove existing service road 1
2. Remove existing service road 2.
3. Construct a 38.6 ac-ft regional detention pond.
4. Install Provo Reservoir Canal crossing.
5. Improve 900 ft of open channel between Provo Reservoir Canal and Camp Williams Road.
6. Install crossing under Camp Williams Road
7. Install storm drain pipe from Camp Williams Crossing to the Iron Horse Boulevard storm drain system.
8. Evaluate and improve Parry Farms Detention Pond.
9. Evaluate and improve storm drain pipe system downstream of Parry Farms detention facility.
10. Mobilization (Assumed for all project alternatives)

By installing a larger detention facility (38.6 ac-ft), the Wood Hollow peak discharge would be reduced to less than Iron Horse Boulevard's entire storm drain system. This would require no improvements or upsizing to the Iron Horse Boulevard's storm drain system.

Total estimated cost for this alternative is 3.01 million dollars (assuming UDOT participation) as detailed in Appendix G. The majority of the total cost (about 51%) is for land acquisition to facilitate the 38.6 ac-ft regional detention pond.

5.4.2 Alternative 2

In a general sense, Alternative 2 follows the Alignment 2 as illustrated in Figure 28. This alternative considers a smaller (7.6 ac-ft) regional detention pond, and proposes construction of another storm drain line within the parcels south of Iron Horse Boulevard (see Figure 32 below).

Figure 32. Alternative 2 Summary over 2006 aerial

As shown in Exhibit 3, this alternative consists of 12 tasks as follows.

1. Remove existing service road 1
2. Remove existing service road 2.
3. Construct a 7.6 ac-ft regional detention pond.
4. Install Provo Reservoir Canal crossing.
5. Improve 1300 ft of open channel between Provo Reservoir Canal and Camp Williams Road.
6. Install an additional crossing under Camp Williams Road
7. Install bubble-up box for connection to Iron Horse Boulevard system
8. Install 2,000 feet of 36" storm drain pipe through PacifiCorp land.
9. Tie to existing SD pipe system at CB 33+92.85
10. Evaluate and improve Parry Farms Detention Pond.
11. Evaluate and improve storm drain pipe system downstream of Parry Farms detention facility.
12. Mobilization (Assumed for all project alternatives)

By installing a smaller detention facility (7.6 ac-ft), the outflow from the pond will be higher than the reduced peak discharge from the otherwise larger detention facility proposed in Alternative 1. As a result, downstream storm drain facilities are undersized. Such facilities include the existing Camp Williams Road crossing (recently constructed) and a portion of the Iron Horse Boulevard storm drain system.

Alternative 2 proposes installation of an additional 36-inch storm drain line underneath the Camp Williams Road (parallel to the recently constructed 42-inch culvert). In this manner the crossing under the road will be adequate to convey Wood Hollow runoff.

Because a portion of the Iron Horse Boulevard storm drain is deficient, Alternative 2 proposes that another storm drain line be constructed through the parcels south of Iron Horse Boulevard as indicated in Figure 32. This storm drain line would serve as the primary source for conveying Wood Hollow runoff to the adequately sized portion of the Iron Horse Boulevard storm drain line (at CB 33+92.85).

Total estimated cost of this alternative is 1.70 million dollars (assuming UDOT participation) as detailed in Appendix G.

5.4.3 Alternative 3

Aside from the imperative improvements mentioned above, Alternative 3 follows Alignment 1 and considers a 7.6 ac-ft regional detention pond and use of the Iron Horse Boulevard storm drain system by means of upsizing the deficient portion of the piped system within Iron Horse Boulevard as depicted in Figure 33.

Figure 33. Alternative 3 Summary over 2006 aerial

As shown in Exhibit 4, this alternative consists of 12 tasks as follows.

1. Remove existing service road 1
2. Remove existing .service road 2.
3. Construct a 7.6 ac-ft regional detention pond.
4. Install Provo Reservoir Canal crossing.

5. Improve 1,300 ft of open channel between Provo Reservoir Canal and Camp Williams Road.
6. Install an additional crossing under Camp Williams Road
7. Upsize SD pipe from Camp Williams crossing to Iron Horse Boulevard.
8. Upsize deficient portion of the Iron Horse Boulevard storm drain system.
9. Tie to existing SD pipe system at CB 33+92.85
10. Evaluate and improve Parry Farms Detention Pond.
11. Evaluate and improve storm drain pipe system downstream of Parry Farms detention facility.
12. Mobilization (assumed for all project alternatives)

Total estimated cost for this alternative is 2.25 million dollars (assuming UDOT participation) as detailed in Appendix G.

5.4.4 Alternative 4

Alternative 4 uses a similar approach to the drainage improvements as described in Alternative 3. The smaller regional detention pond would be constructed and instead of upsizing the deficient pipes in the Iron Horse Boulevard storm drainage system, Alternative 4 proposes to install a storm drain pipe system parallel to the deficient portion of the storm drain system as shown in below in Figure 34.

Figure 34. Alternative 4 summary over 2006 aerial

As shown in Exhibit 5, this alternative consists of 12 tasks as follows.

1. Remove existing service road 1
2. Remove existing service road 2.
3. Construct a 7.6 ac-ft regional detention pond.
4. Install Provo Reservoir Canal crossing.

5. Improve 1,300 ft of open channel between Provo Reservoir Canal and Camp Williams Road.
6. Install an additional crossing under Camp Williams Road
7. Install additional (parallel) SD pipe from Camp Williams crossing to Iron Horse Boulevard.
8. Install additional (parallel) SD pipe along deficient portion of the Iron Horse Boulevard storm drain system.
9. Tie additional line to existing SD pipe system at CB 33+92.85
10. Evaluate and improve Parry Farms Detention Pond.
11. Evaluate and improve storm drain pipe system downstream of Parry Farms detention facility.
12. Mobilization (assumed for all project alternatives)

Total estimated cost for this alternative is 1.76 million dollars (assuming UDOT participation) as detailed in Appendix G.

5.5 Selected Alternative

For purposes of this report, the alternative with the least estimated project cost is the preferred alternative. As such, Alternative 2 is the preferred alternative.

Table 17. Alternative Cost Summary

Alternative Project *Cost (Million Dollars)			
1	2	3	4
$3.01	$1.70	$2.25	$1.76

*Assuming UDOT participation

Section 6 - Proposed Improvements

This section identifies and describes the proposed improvements that will allow safe conveyance of Wood Hollow's runoff to the Jordan River. It includes criteria for design of proposed facilities and descriptions of specific improvements for each problem area.

6.1 Mitigate Service Road Crossing 1

The purpose of the service roads is not completely known. It is assumed that both service roads have served the Jordan Valley Water Conservancy District (JVWCD) and the current nearby mining activities. These service roads are expected to be abandoned with the construction of the proposed Herriman-Camp Williams Road based on meetings and discussions with the County, JVWCD, Bluffdale City and Herriman City.

The dirt road crossing the Wood Hollow drainage needs to be removed or an adequate culvert/bridge should be constructed to convey the Wood Hollow flows. For purposes of this report, it was assumed that the roads would be completely removed. The earthwork required to restore the historic nature of the drainage channel at the access roads was calculated and used to determine the estimated cost for this improvement. The total estimated cost to improve Service Road 1 is $20,500

6.2 Mitigate Service Road Crossing 2

Like service road 1, this road is proposed to be removed at the crossing as described above. The total estimated cost to mitigate Service Road 2 is $26,230.

6.3 Detention Pond

The regional detention pond was modeled and sized using the Wood Hollow future conditions hydrology model (HEC-HMS software). The required storage volume of the pond is 7.6 ac-ft, which will discharge a maximum of 146.7 cfs for the 100-yr 12-hr storm event (governing storm).

6.3.1 Pond Configuration

In order for the pond to function as designed, the configuration must comply with the stage-storage relationship that is provided in Regional Detention Pond Calculations as provided in Appendix A. Feasibility for such a configuration has been explored and verified for the indicated location.

6.3.2 Regional Detention Pond Outlet Structure

A restricted orifice approach was chosen for this pond. There are a total of two outlets for this pond. The first outlet is the orifice at the bottom of the pond, which serves as the primary outlet. The other outlet is the emergency spillway proposed at the top of the pond.

Pond Orifice Structure

A few typical inlets at the bottom of the pond will fulfill the intent of the calculated orifice as long as it has an effective opening of exactly 12 ft^2 as calculated and shown in Appendix A. This may require various inlets at the bottom of the pond. It is imperative that the inlets be protected from debris and other nuisance objects that may clog the inlet.

Emergency Spillway

The emergency spillway shall be constructed such that it will safely handle and direct at least 175 cfs to the Provo Reservoir (or Welby-Jacobs canal).

6.3.3 Tributary Area to Regional Detention Pond

It is critical to note that only the Wood Hollow drainage areas (including MVC tributary areas to Wood Hollow drainage flow path) are considered as tributary to the proposed regional detention pond. Adjacent tributary areas affected by the MVC are not considered in sizing the regional detention pond as shown in Figure 35. It is assumed and that UDOT shall manage runoff from such drainage areas not tributary to the regional detention pond by safely conveying the runoff across the MVC to its natural drainage path. If, however, UDOT proposes to manage the adjacent drainage areas in a manner such that the regional detention pond shall intercept other drainage areas, efforts must be made to evaluate and adjust the regional detention pond accordingly.

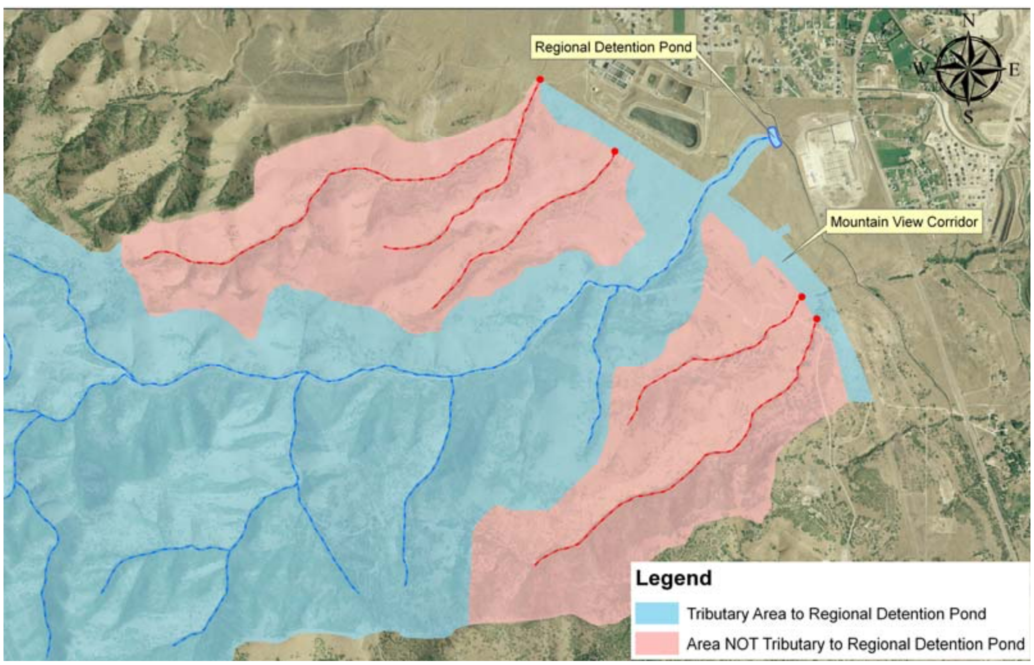

Figure 35. Tributary areas to the proposed regional detention pond over 2006 aerial

6.3.4 Downstream Effects of Regional Detention

The regional detention pond is proposed to restrict flow by means of placing a restricted orifice at the bottom of the pond. This method not only restricts the flow, but also imposes a substantial delay in the timing of the peak discharge leaving the detention pond. This is a desirable result for this particular project.

For example, the red line shown in Figure 36 represents the hydrograph for runoff through the Iron Horse Boulevard storm drain system from all of Wood Hollow's tributary area upstream of Parry Farms, or "Upstream Basins". The second peak is a result of all the flow leaving the regional detention pond and entering the Iron Horse storm drain system. The green line represents the runoff into the storm drain system from the Parry Farms development. The blue line is the overall hydrograph of the Iron Horse Boulevard storm drain system including runoff from both tributary areas above Parry Farms and Parry Farms development. Notice that the majority of Parry Farms runoff (including its peak discharge) passes through the system approximately four hours before runoff from the "Upstream Basins" (including flow coming out of the regional detention pond) passes through the system.

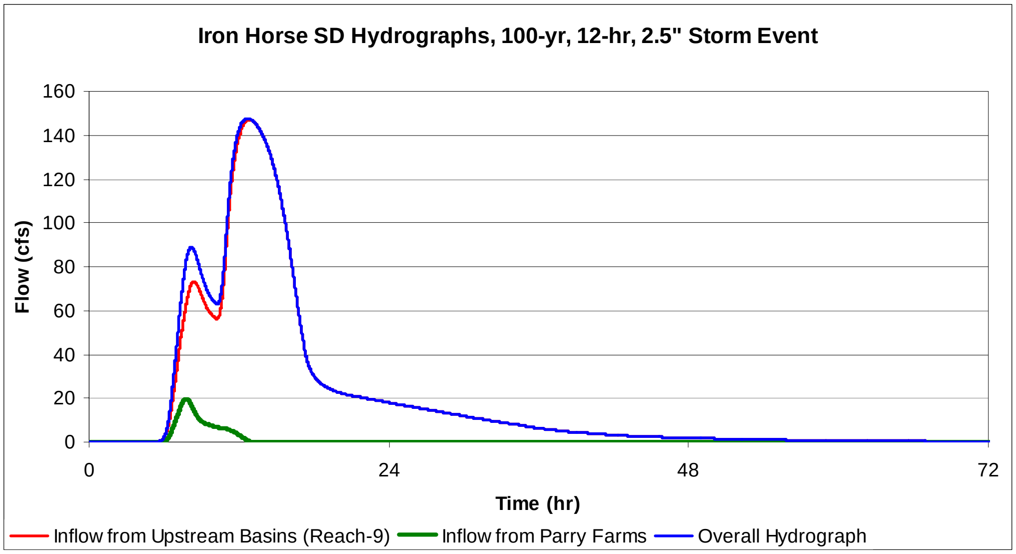

Figure 36. Iron Horse Boulevard storm drain hydrographs

This means that the peak discharges from the Parry Farms and Upstream Basins do not have a cumulative effect and therefore do not warrant additional restriction in the regional detention pond to facilitate the Iron Horse storm drain system for the runoff from the Parry Farms development.

6.4 Provo-Reservoir Canal crossing

It is proposed that the flow from the regional detention pond exit and cross underneath the Provo-Reservoir Canal by constructing a storm drain pipe from the outlet structure of the pond to the other side of the canal. For construction cost purposes, a 48" RCP pipe was sized for this crossing assuming a minimum slope of 1.0%.

It was also assumed that a concrete liner (flume) be constructed along 60 feet of the canal in the area above the canal crossing. This is recommended to protect the existing canal from the proposed storm drain crossing improvements.

6.5 Open Channel Improvements

The channel located immediately downstream of the proposed location of the regional detention pond currently has only 4.9 cfs of safe capacity and 30.9 cfs total capacity (as previously defined). Because the open channel is immediately downstream of the regional detention pond, the channel will be subject to the flows that leave the detention facility. As mentioned above, the regional detention pond is designed to release a maximum 146.7 cfs. Therefore significant channel improvements are recommended.

Based on survey data and HEC-RAS analysis, lengths of required improvement were determined for each alternative. About 75% or 1,300 feet of the open channel will require improvements to safely accommodate the proposed flows. Locations and extent of the improvements may determined by use and interpretation of the attached HEC-RAS model that was developed for this project. For simplicity, it is assumed that the entire channel (1,780 feet) will be improved to safely handle 146.7 cfs.

6.6 Camp Williams Road Crossing

As previously described, currently the Wood Hollow flows are not conveyed across the Camp Williams Road. No evidence of an outlet was found on earlier site visits. Currently a new culvert exists under Camp Williams Road. However, it is intentionally blocked to prevent Wood Hollow flows from passing through until it is decided that downstream facilities and stakeholders will not be adversely affected. This culvert has capacity of approximately 80 cfs. In addition to uncovering this culvert, it is recommended that another culvert crossing be constructed in order for the combined capacity of the two culverts to safely convey Wood Hollow's runoff.

6.7 Bubble-Up Box

The proposed bypass storm drain line is not intended to completely and independently handle Wood Hollow drainage. In fact, the proposed bypass line has less capacity than the total anticipated Wood Hollow peak runoff. However, the combined capacity of the two lines (proposed bypass line and the existing deficient storm drain line) may convey Wood Hollow drainage. The proposed bubble-up box is intended to provide passage to the undersized line once the bypass line is at capacity. The conceptual layout and purpose of this structure may be seen in the provided schematic in Figure 37.

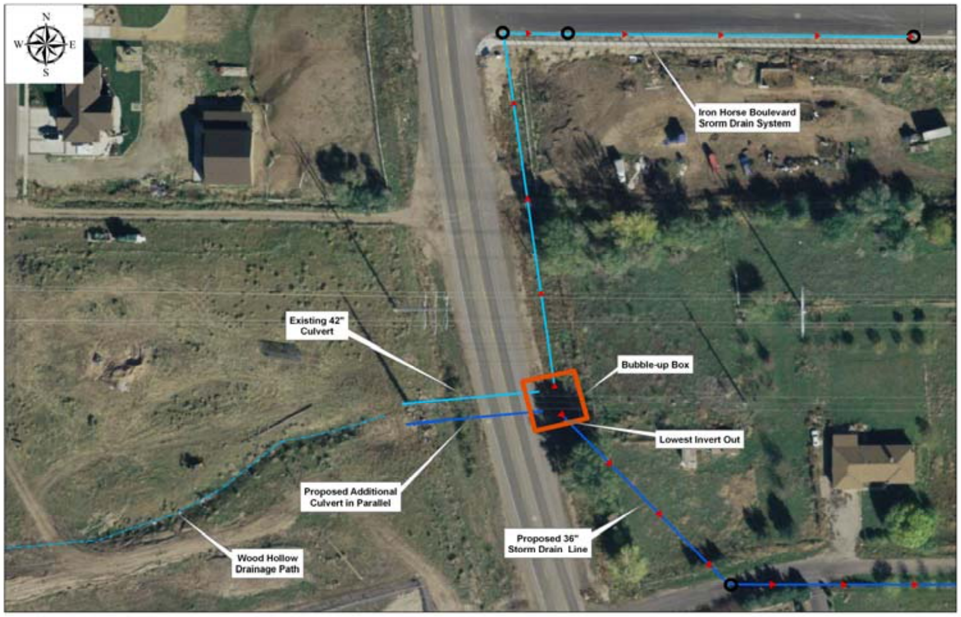

Figure 37. Proposed Bubble-Up Box configuration over one foot HRO aerial

6.8 SD Line in Parcels South of Iron Horse Boulevard

As shown in Figure 27, the capacity of the undersized portion of the line is 82 cfs. The 2,000 feet proposed 36-inch bypass line would have a total capacity of about 100 cfs. Therefore the combined capacity of the proposed SD line and the deficient Iron Horse Boulevard SD line would be about 180 cfs. By means of the combined capacity of the two SD lines, the Wood Hollow flows may be safely conveyed downstream to the tie-in point with the more capable portion of the Iron Horse Boulevard SD system (at CB 33+92.85). The minimum permissible slope of this line must be 3 percent.

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Appendix A
Detention Pond Stage Storage Discharge Data

Regional Detention Pond Discharge Calculations

Inlet Elev. =	4718.33	
Discharge Coeff. =	0.60	ft
Total Area =	12.0000	ft2

Emergency Spillway Elevation =	4725	ft
Weir Length =	15	
Weir Type =	Broad Crested	
Weir coefficient of discharge =	2.62	

	Actual Detention Size				
				VOLUME	
	STAGE	AREA	INC	CUMM	
	ft	ft^2	ft^3	ft^3	ac-ft
	4718.00	12168.76	0.00	0.00	0.000
	4718.50	32145.24	11078.50	11078.50	0.254
	4719.00	43401.99	18886.81	29965.31	0.688
	4719.50	44833.65	22058.91	52024.22	1.194
	4720.00	46279.44	22778.27	74802.49	1.717
	4720.50	47739.34	23504.70	98307.19	2.257
	4721.00	49213.36	24238.18	122545.36	2.8133
	4721.50	50701.50	24978.72	147524.08	3.3867
	4722.00	52203.76	25726.32	173250.39	3.9773
	4722.50	53720.14	26480.98	199731.37	4.5852
	4723.00	55250.64	27242.70	226974.06	5.2106
	4723.50	56795.25	28011.47	254985.53	5.8537
	4724.00	58353.99	28787.31	283772.84	6.5145
Peak Elevation = 4724.8'	4724.50	59926.84	29570.21	313343.05	7.1934
Emergency Spillway Elevation =	4725.00	61513.81	30360.16	343703.21	7.8903
	4725.50	61513.81	30756.91	374460.12	8.5964
	4726.00	61514.81	30757.16	**405217.27**	**9.3025**

Head	Stage	Discharge	Head	Discharge	Total System Discharge
0	4718.00	0.00	0.00	0.00	**0.00**
0.17	4718.50	23.76	0.00	0.00	**23.76**
0.67	4719.00	47.16	0.00	0.00	**47.16**
1.17	4719.50	62.32	0.00	0.00	**62.32**
1.67	4720.00	74.46	0.00	0.00	**74.46**
2.17	4720.50	84.87	0.00	0.00	**84.87**
2.67	4721.00	94.14	0.00	0.00	**94.14**
3.17	4721.50	102.58	0.00	0.00	**102.58**
3.67	4722.00	110.37	0.00	0.00	**110.37**
4.17	4722.50	117.65	0.00	0.00	**117.65**
4.67	4723.00	124.51	0.00	0.00	**124.51**
5.17	4723.50	131.00	0.00	0.00	**131.00**
5.67	4724.00	137.19	0.00	0.00	**137.19**
6.17	4724.50	143.11	0.00	0.00	**143.11**
6.67	4725.00	148.80	0.00	0.00	**148.80**
7.17	4725.5	154.2754377	0.50	5.30	**159.58**
7.67	4726	159.56	1.00	15.00	**174.56**

Name: **Reservoir 1**

Location: **Sub Basin 10**

Allowable Discharge Rate =	0.05	cfs/acre
Area served =	200.25	acres
Allowable Discharge Rate =	10.01	cfs
Area of the Pond =	105000	square feet
Orifice Parameters		
Shape	Circular	
Diameter	13.45	inches
Radius	0.56	feet
Cd =	0.6	
Area=	0.99	square feet
g=	32.2	

Stage (feet)	Storage (cubic feet)	Storage (acre-feet)	Discharge (cfs)
0	0	0.00	0
0.75	78750	1.81	2.07
1	105000	2.41	3.15
2	210000	4.82	5.70
3	315000	7.23	7.42
4	420000	9.64	8.81
5	525000	12.05	10.01

*For the purposes of this study, all detention pond stage-storage curves are developed assuming a rectangular pond shape.

Name: **Reservoir 2**

Location: **Sub Basin 11**

Allowable Discharge Rate =	0.05	cfs/acre
Area served =	136.28	acres
Allowable Discharge Rate =	6.81	cfs
Area of the Pond =	75000	square feet
Orifice Parameters		
Shape	Circular	
Diameter	11	inches
Radius	0.46	feet
Cd =	0.6	
Area=	0.66	square feet
g=	32.2	

Stage (feet)	Storage (cubic feet)	Storage (acre-feet)	Discharge (cfs)
0	0	0.00	0
0.5	37500	0.86	0.65
1	75000	1.72	2.34
2	150000	3.44	3.95
3	225000	5.17	5.07
4	300000	6.89	5.98
5	375000	8.61	6.77

Name: **Reservoir 3**

Location: **Sub Basin 15**

Allowable Discharge Rate =	0.05	cfs/acre
Area served =	29.03	acres
Allowable Discharge Rate =	1.45	cfs
Area of the Pond =	20000	square feet
Orifice Parameters		
Shape	Circular	
Diameter	5	inches
Radius	0.21	feet
Cd =	0.6	
Area=	0.14	square feet
g=	32.2	

Stage (feet)	Storage (cubic feet)	Storage (acre-feet)	Discharge (cfs)
0	0	0.00	0
0.5	10000	0.23	0.35
1	20000	0.46	0.58
2	40000	0.92	0.88
3	60000	1.38	1.10
4	80000	1.84	1.28
5	100000	2.30	1.44

Name: **Reservoir 4**

Location: **Sub Basin 6**

Allowable Discharge Rate =	0.05	cfs/acre
Area served =	109.92	acres
Allowable Discharge Rate =	5.50	cfs
Area of the Pond =	60000	square feet
Orifice Parameters		
Shape	Circular	
Diameter	9.9	inches
Radius	0.41	feet
Cd =	0.6	
Area=	0.53	square feet
g=	32.2	

Stage (feet)	Storage (cubic feet)	Storage (acre-feet)	Discharge (cfs)
0	0	0.00	0
0.5	30000	0.69	0.76
1	60000	1.38	1.97
2	120000	2.75	3.24
3	180000	4.13	4.13
4	240000	5.51	4.87
5	300000	6.89	5.50

Name:	**Reservoir 5**
Location:	**Provo_Reservoir**

Allowable Discharge Rate =	0.05	cfs/acre
Area served =	11.61	acres
Allowable Discharge Rate =	0.58	cfs
Area of the Pond =	4000	square feet
Orifice Parameters		
Shape	Circular	
Diameter	3.2	inches
Radius	0.13	feet
Cd =	0.6	
Area=	0.05	square feet
g=	32.2	

Stage (feet)	Storage (cubic feet)	Storage (acre-feet)	Discharge (cfs)
0	0	0.00	0
0.5	2000	0.05	0.16
1	4000	0.09	0.25
2	8000	0.18	0.36
3	12000	0.28	0.45
4	16000	0.37	0.52
5	20000	0.46	0.58

Name: **Reservoir 6**

Location: **Power Plant**

Allowable Discharge Rate =	0.05	cfs/acre
Area served =	12.83	acres
Allowable Discharge Rate =	0.64	cfs
Area of the Pond =	2500	square feet
Orifice Parameters		
Shape	Circular	
Diameter	3.3	inches
Radius	0.14	feet
Cd =	0.6	
Area=	0.06	square feet
g=	32.2	

Stage (feet)	Storage (cubic feet)	Storage (acre-feet)	Discharge (cfs)
0	0	0.00	0
0.5	1250	0.03	0.17
1	2500	0.06	0.27
2	5000	0.11	0.39
3	7500	0.17	0.48
4	10000	0.23	0.56
5	12500	0.29	0.63

Name: **Rosecrest/ South Hills Pond**

Location: **Rosecrest/South Hills_2**

Allowable Discharge Rate =	0.05	cfs/acre
Area served =	82.68	acres
Allowable Discharge Rate =	4.13	cfs
Area of the Pond =	55000	square feet
Orifice Parameters		
Shape	Circular	
Diameter	8.53	inches
Radius	0.36	feet
Cd =	0.6	
Area=	0.40	square feet
g=	32.2	

Stage (feet)	Storage (cubic feet)	Storage (acre-feet)	Discharge (cfs)
0	0	0.00	0
0.5	27500	0.63	0.73
1	55000	1.26	1.53
2	110000	2.53	2.45
3	165000	3.79	3.11
4	220000	5.05	3.65
5	275000	6.31	4.12

Appendix B
Selected HEC-HMS Model Results

Project: Wood Hollow   Simulation Run: Existing 100-Year, 12-Hour

Start of Run: 01Jan2000, 00:00
End of Run: 05Jan2000, 00:00
Compute Time: 19Mar2009, 16:42:59

Basin Model: Wood Hollow Existing
Meterologic Model 100-Year, 12-Hr, 2.5"
Control Specifications: Control 1

Volume Units: AC-FT

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (AC-FT)
Junction-1	1.87	52.4	01Jan2000, 09:49	20.002
Junction-2	3.89	119.7	01Jan2000, 09:49	45.538
Junction-3	5.03	136.9	01Jan2000, 10:08	52.539
Junction-4	5.21	139.7	01Jan2000, 10:14	53.482
Junction-7	5.26	140.5	01Jan2000, 10:21	53.778
Junction-8	5.26	140.5	01Jan2000, 10:21	53.778
Junction-9	5.26	140.5	01Jan2000, 10:22	53.778
Parry Farms	0.11	19.8	01Jan2000, 07:47	4.622
Parry Farms Detention Pond	5.37	147.2	01Jan2000, 10:21	58.401
Power Plant	0.02	0.5	01Jan2000, 08:18	0.163
Provo-Reservoir	0.03	0.4	01Jan2000, 10:45	0.132
Provo-Reservoir Canal	5.24	140.1	01Jan2000, 10:16	53.614
Reach-1	1.87	52.4	01Jan2000, 10:04	20.002
Reach-2	3.89	119.7	01Jan2000, 10:02	45.54
Reach-3	5.03	136.9	01Jan2000, 10:13	52.539
Reach-4	5.21	139.7	01Jan2000, 10:16	53.482
Reach-5	5.24	140.1	01Jan2000, 10:20	53.615
Reach-6	5.26	140.5	01Jan2000, 10:21	53.778
Reach-7	5.26	140.5	01Jan2000, 10:21	53.778
Reach-8	5.26	140.5	01Jan2000, 10:22	53.778
Reach-9	5.26	140.5	01Jan2000, 10:22	53.778
Redwood Road	5.26	140.5	01Jan2000, 10:20	53.778
Subbasin-1	1.1	33.7	01Jan2000, 09:46	12.866
Subbasin-2	0.77	18.8	01Jan2000, 09:58	7.136
Subbasin-3	1.12	44.1	01Jan2000, 09:26	16.133
Subbasin-4	0.9	24.7	01Jan2000, 09:48	9.402
Subbasin-5	1.14	19	01Jan2000, 11:19	6.999

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (AC-FT)
Subbasin-6	0.18	2.8	01Jan2000, 10:53	0.942

Project: Wood Hollow   Simulation Run: Existing 100-Year, 24-Hour

Start of Run: 01Jan2000, 00:00
End of Run: 05Jan2000, 00:00
Compute Time: 19Mar2009, 16:56:45

Basin Model: Wood Hollow Existing
Meterologic Model 100-Year, 24-Hr, 2.75"
Control Specifications: Control 1

Volume Units: AC-FT

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (AC-FT)
Junction-1	1.87	47.4	01Jan2000, 16:54	28.005
Junction-2	3.89	107.9	01Jan2000, 16:56	62.973
Junction-3	5.03	123.5	01Jan2000, 17:13	73.637
Junction-4	5.21	125.7	01Jan2000, 17:18	75.113
Junction-7	5.26	126.4	01Jan2000, 17:25	75.565
Junction-8	5.26	126.4	01Jan2000, 17:25	75.565
Junction-9	5.26	126.4	01Jan2000, 17:26	75.565
Parry Farms	0.11	12.7	01Jan2000, 15:10	5.599
Parry Farms Detention Pond	5.37	131.8	01Jan2000, 17:25	81.164
Power Plant	0.02	0.5	01Jan2000, 15:43	0.237
Provo-Reservoir	0.03	0.4	01Jan2000, 16:13	0.213
Provo-Reservoir Canal	5.24	126.1	01Jan2000, 17:21	75.327
Reach-1	1.87	47.4	01Jan2000, 17:10	28.005
Reach-2	3.89	107.9	01Jan2000, 17:10	62.975
Reach-3	5.03	123.5	01Jan2000, 17:18	73.638
Reach-4	5.21	125.7	01Jan2000, 17:21	75.114
Reach-5	5.24	126.1	01Jan2000, 17:24	75.328
Reach-6	5.26	126.4	01Jan2000, 17:25	75.565
Reach-7	5.26	126.4	01Jan2000, 17:25	75.565
Reach-8	5.26	126.4	01Jan2000, 17:26	75.565
Reach-9	5.26	126.4	01Jan2000, 17:27	75.565
Redwood Road	5.26	126.4	01Jan2000, 17:24	75.565
Subbasin-1	1.1	30.4	01Jan2000, 16:54	17.808
Subbasin-2	0.77	17	01Jan2000, 16:56	10.196
Subbasin-3	1.12	39.2	01Jan2000, 16:38	21.756
Subbasin-4	0.9	22.4	01Jan2000, 16:53	13.212
Subbasin-5	1.14	15.9	01Jan2000, 17:37	10.663

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (AC-FT)
Subbasin-6	0.18	2.4	01Jan2000, 16:40	1.476

Project: Wood Hollow   Simulation Run: Future_Design_100-yr, 12-hr

Start of Run: 01Jan2000, 00:00
End of Run: 05Jan2000, 00:00
Compute Time: 13Jan2009, 11:00:03

Basin Model: WH_Future_With Regional Det
Meterologic Model 100-Year, 12-Hr, 2.5"
Control Specifications: Control 1

Volume Units: AC-FT

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (AC-FT)
Camp Williams Road	5.5922	147.3	01Jan2000, 12:47	112.007
Junction-1	1.86	54.9	01Jan2000, 09:40	32.864
Junction-10	5.5922	147.3	01Jan2000, 12:49	112.007
Junction-11	0.31	9.9	01Jan2000, 12:16	15.576
Junction-12	0.21	6.7	01Jan2000, 12:17	11.153
Junction-13	2.07	60.9	01Jan2000, 09:48	44.017
Junction-14	0.05	1.3	01Jan2000, 12:16	2.37
Junction-15	0.1	17.7	01Jan2000, 08:10	4.741
Junction-2	3.89	125.8	01Jan2000, 09:40	70.123
Junction-3	4.94	145.4	01Jan2000, 11:26	77.602
Junction-4	5.11	150.4	01Jan2000, 11:31	85.658
Junction-5	5.11	150.4	01Jan2000, 11:33	85.658
Junction-6	5.227	153.9	01Jan2000, 11:34	91.857
Junction-7	5.5472	172.4	01Jan2000, 11:27	110.914
Junction-8	5.5922	147.3	01Jan2000, 12:48	112.007
Junction-9	5.5922	147.3	01Jan2000, 12:48	112.007
Mountain View Corridor North	0.1981	46.2	01Jan2000, 07:57	11.79
Mountain View Corridor South	0.1221	30.7	01Jan2000, 07:42	7.267
Parry Farms	0.11	19.8	01Jan2000, 07:47	4.622
Parry Farms Detention Pond	5.7022	147.7	01Jan2000, 12:43	116.629
Power Plant	0.02	2	01Jan2000, 07:55	0.486
Provo-Reservoir	0.025	2.5	01Jan2000, 07:58	0.607
Provo-Reservoir Canal	5.5722	146.7	01Jan2000, 12:44	111.521
Reach-1	1.86	54.9	01Jan2000, 09:46	32.864
Reach-10	5.11	150.4	01Jan2000, 11:33	85.658
Reach-11	5.11	150.4	01Jan2000, 11:34	85.658
Reach-12	5.227	153.9	01Jan2000, 11:35	91.857

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (AC-FT)
Reach-13	0.31	9.9	01Jan2000, 12:21	15.576
Reach-14	0.21	6.7	01Jan2000, 12:29	11.153
Reach-15	2.07	60.9	01Jan2000, 09:57	44.017
Reach-16	0.05	1.3	01Jan2000, 12:18	2.37
Reach-17	0.1	17.7	01Jan2000, 08:10	4.741
Reach-2	3.89	125.8	01Jan2000, 11:28	70.133
Reach-3	4.94	145.4	01Jan2000, 11:31	77.602
Reach-4	5.5472	172.4	01Jan2000, 11:29	110.915
Reach-5	5.5722	146.7	01Jan2000, 12:47	111.521
Reach-6	5.5922	147.3	01Jan2000, 12:48	112.007
Reach-7	5.5922	147.3	01Jan2000, 12:48	112.007
Reach-8	5.5922	147.3	01Jan2000, 12:49	112.007
Reach-9	5.5922	147.3	01Jan2000, 12:50	112.007
Regional Detention	5.5722	146.7	01Jan2000, 12:44	111.521
Reservoir-1	0.31	9.9	01Jan2000, 12:16	15.576
Reservoir-2	0.21	6.7	01Jan2000, 12:17	11.153
Reservoir-3	0.05	1.3	01Jan2000, 12:16	2.37
Reservoir-4	0.17	5.1	01Jan2000, 12:27	8.056
Reservoir-5	0.025	0.5	01Jan2000, 12:03	0.607
Reservoir-6	0.02	0.6	01Jan2000, 11:39	0.486
Rosecrest/South Hills_1	0.1	17.7	01Jan2000, 08:10	4.741
Rosecrest/South Hills_2	0.017	6	01Jan2000, 07:23	1.46
Rosecrest/South Hills Deten	0.117	3.5	01Jan2000, 12:23	6.199
Subbasin-1	0.78	27.9	01Jan2000, 09:24	10.152
Subbasin-10	0.31	62	01Jan2000, 07:57	15.581
Subbasin-11	0.21	44.4	01Jan2000, 07:57	11.178
Subbasin-15	0.05	9.8	01Jan2000, 07:51	2.37
Subbasin-2	0.77	18.8	01Jan2000, 09:58	7.136
Subbasin-3	1.12	44.1	01Jan2000, 09:26	16.133
Subbasin-4	0.65	21.2	01Jan2000, 09:18	7.603
Subbasin-5	1.05	19.9	01Jan2000, 10:57	7.469
Subbasin-6	0.17	30.4	01Jan2000, 08:08	8.059

Project: Wood Hollow   Simulation Run: Future_Design_100-yr, 24-hr

Start of Run: 01Jan2000, 00:00   Basin Model: WH_Future_With Regional Det
End of Run: 05Jan2000, 00:00   Meterologic Model 100-Year, 24-Hr, 2.75"
Compute Time: 19Jan2009, 17:11:58   Control Specifications: Control 1

Volume Units: AC-FT

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (AC-FT)
Camp Williams Road	5.5922	138.7	01Jan2000, 20:07	142.904
Junction-1	1.86	50.2	01Jan2000, 16:47	42.635
Junction-10	5.5922	138.7	01Jan2000, 20:09	142.903
Junction-11	0.31	9.6	01Jan2000, 22:17	18.578
Junction-12	0.21	6.6	01Jan2000, 22:22	13.226
Junction-13	2.07	56	01Jan2000, 16:56	55.861
Junction-14	0.05	1.3	01Jan2000, 22:53	2.842
Junction-15	0.1	12.2	01Jan2000, 15:27	5.684
Junction-2	3.89	114.2	01Jan2000, 16:49	90.982
Junction-3	4.94	129.9	01Jan2000, 18:38	102.086
Junction-4	5.11	134.7	01Jan2000, 18:43	111.742
Junction-5	5.11	134.7	01Jan2000, 18:45	111.741
Junction-6	5.227	138.1	01Jan2000, 18:46	119.087
Junction-7	5.5472	154.1	01Jan2000, 18:44	141.513
Junction-8	5.5922	138.7	01Jan2000, 20:08	142.903
Junction-9	5.5922	138.7	01Jan2000, 20:08	142.903
Mountain View Corridor North	0.1981	29.7	01Jan2000, 15:14	13.874
Mountain View Corridor South	0.1221	18.7	01Jan2000, 15:04	8.552
Parry Farms	0.11	12.7	01Jan2000, 15:10	5.599
Parry Farms Detention Pond	5.7022	142.6	01Jan2000, 20:09	148.502
Power Plant	0.02	1.4	01Jan2000, 15:14	0.619
Provo-Reservoir	0.025	1.8	01Jan2000, 15:17	0.773
Provo-Reservoir Canal	5.5722	138.2	01Jan2000, 20:04	142.285
Reach-1	1.86	50.2	01Jan2000, 16:54	42.635
Reach-10	5.11	134.7	01Jan2000, 18:45	111.741
Reach-11	5.11	134.7	01Jan2000, 18:46	111.741
Reach-12	5.227	138.1	01Jan2000, 18:47	119.087

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (AC-FT)
Reach-13	0.31	9.6	01Jan2000, 22:23	18.578
Reach-14	0.21	6.6	01Jan2000, 22:34	13.226
Reach-15	2.07	56	01Jan2000, 17:04	55.861
Reach-16	0.05	1.3	01Jan2000, 22:56	2.842
Reach-17	0.1	12.2	01Jan2000, 15:27	5.684
Reach-2	3.89	114.2	01Jan2000, 18:40	90.979
Reach-3	4.94	129.9	01Jan2000, 18:42	102.086
Reach-4	5.5472	154.1	01Jan2000, 18:47	141.513
Reach-5	5.5722	138.2	01Jan2000, 20:07	142.285
Reach-6	5.5922	138.7	01Jan2000, 20:08	142.903
Reach-7	5.5922	138.7	01Jan2000, 20:08	142.903
Reach-8	5.5922	138.7	01Jan2000, 20:09	142.903
Reach-9	5.5922	138.7	01Jan2000, 20:10	142.903
Regional Detention	5.5722	138.2	01Jan2000, 20:04	142.285
Reservoir-1	0.31	9.6	01Jan2000, 22:17	18.578
Reservoir-2	0.21	6.6	01Jan2000, 22:22	13.226
Reservoir-3	0.05	1.3	01Jan2000, 22:53	2.842
Reservoir-4	0.17	5	01Jan2000, 22:34	9.656
Reservoir-5	0.025	0.5	01Jan2000, 22:06	0.773
Reservoir-6	0.02	0.6	01Jan2000, 19:09	0.619
Rosecrest/South Hills_1	0.1	12.2	01Jan2000, 15:27	5.684
Rosecrest/South Hills_2	0.017	3.5	01Jan2000, 14:35	1.668
Rosecrest/South Hills Deten	0.117	3.5	01Jan2000, 22:40	7.346
Subbasin-1	0.78	24.9	01Jan2000, 16:37	13.861
Subbasin-10	0.31	40.6	01Jan2000, 15:16	18.591
Subbasin-11	0.21	28.8	01Jan2000, 15:15	13.274
Subbasin-15	0.05	6.3	01Jan2000, 15:11	2.842
Subbasin-2	0.77	17	01Jan2000, 16:56	10.196
Subbasin-3	1.12	39.2	01Jan2000, 16:38	21.756
Subbasin-4	0.65	19.1	01Jan2000, 16:31	10.523
Subbasin-5	1.05	17.4	01Jan2000, 17:17	11.107
Subbasin-6	0.17	20.8	01Jan2000, 15:25	9.663

Project: Wood Hollow   Simulation Run: Future 100-year, 12-hour

Start of Run: 01Jan2000, 00:00
End of Run: 05Jan2000, 00:00
Compute Time: 21Jan2009, 14:12:36

Basin Model: Wood Hollow_Future_Mitigated
Meterologic Model   100-Year, 12-Hr, 2.5"
Control Specifications: Control 1

Volume Units: AC-FT

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (AC-FT)
Junction-1	1.86	54.9	01Jan2000, 09:40	32.864
Junction-10	5.5922	173.6	01Jan2000, 11:34	112.007
Junction-11	0.31	9.9	01Jan2000, 12:16	15.576
Junction-12	0.21	6.7	01Jan2000, 12:17	11.153
Junction-13	2.07	60.9	01Jan2000, 09:48	44.017
Junction-14	0.05	1.3	01Jan2000, 12:16	2.37
Junction-15	0.1	17.7	01Jan2000, 08:10	4.741
Junction-2	3.89	125.8	01Jan2000, 09:40	70.123
Junction-3	4.94	145.4	01Jan2000, 11:26	77.602
Junction-4	5.11	150.4	01Jan2000, 11:31	85.658
Junction-5	5.11	150.4	01Jan2000, 11:33	85.658
Junction-6	5.227	153.9	01Jan2000, 11:34	91.857
Junction-7	5.5472	172.4	01Jan2000, 11:27	110.914
Junction-8	5.5922	173.6	01Jan2000, 11:33	112.007
Junction-9	5.5922	173.6	01Jan2000, 11:33	112.007
Mountain View Corridor North	0.1981	46.2	01Jan2000, 07:57	11.79
Mountain View Corridor South	0.1221	30.7	01Jan2000, 07:42	7.267
Parry Farms	0.11	19.8	01Jan2000, 07:47	4.622
Parry Farms Detention Pond	5.7022	178.4	01Jan2000, 11:33	116.63
Power Plant	0.02	2	01Jan2000, 07:55	0.486
Provo-Reservoir	0.025	2.5	01Jan2000, 07:58	0.607
Provo-Reservoir Canal	5.5722	172.9	01Jan2000, 11:29	111.522
Reach-1	1.86	54.9	01Jan2000, 09:46	32.864
Reach-10	5.11	150.4	01Jan2000, 11:33	85.658
Reach-11	5.11	150.4	01Jan2000, 11:34	85.658
Reach-12	5.227	153.9	01Jan2000, 11:35	91.857
Reach-13	0.31	9.9	01Jan2000, 12:21	15.576

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (AC-FT)
Reach-14	0.21	6.7	01Jan2000, 12:29	11.153
Reach-15	2.07	60.9	01Jan2000, 09:57	44.017
Reach-16	0.05	1.3	01Jan2000, 12:18	2.37
Reach-17	0.1	17.7	01Jan2000, 08:10	4.741
Reach-2	3.89	125.8	01Jan2000, 11:28	70.133
Reach-3	4.94	145.4	01Jan2000, 11:31	77.602
Reach-4	5.5472	172.4	01Jan2000, 11:29	110.915
Reach-5	5.5722	172.9	01Jan2000, 11:32	111.522
Reach-6	5.5922	173.6	01Jan2000, 11:33	112.007
Reach-7	5.5922	173.6	01Jan2000, 11:33	112.007
Reach-8	5.5922	173.6	01Jan2000, 11:34	112.007
Reach-9	5.5922	173.5	01Jan2000, 11:35	112.007
Redwood Road	5.5922	173.6	01Jan2000, 11:32	112.007
Reservoir-1	0.31	9.9	01Jan2000, 12:16	15.576
Reservoir-2	0.21	6.7	01Jan2000, 12:17	11.153
Reservoir-3	0.05	1.3	01Jan2000, 12:16	2.37
Reservoir-4	0.17	5.1	01Jan2000, 12:27	8.056
Reservoir-5	0.025	0.5	01Jan2000, 12:03	0.607
Reservoir-6	0.02	0.6	01Jan2000, 11:39	0.486
Rosecrest/South Hills_1	0.1	17.7	01Jan2000, 08:10	4.741
Rosecrest/South Hills_2	0.017	6	01Jan2000, 07:23	1.46
Rosecrest/South Hills Deten	0.117	3.5	01Jan2000, 12:23	6.199
Subbasin-1	0.78	27.9	01Jan2000, 09:24	10.152
Subbasin-10	0.31	62	01Jan2000, 07:57	15.581
Subbasin-11	0.21	44.4	01Jan2000, 07:57	11.178
Subbasin-15	0.05	9.8	01Jan2000, 07:51	2.37
Subbasin-2	0.77	18.8	01Jan2000, 09:58	7.136
Subbasin-3	1.12	44.1	01Jan2000, 09:26	16.133
Subbasin-4	0.65	21.2	01Jan2000, 09:18	7.603
Subbasin-5	1.05	19.9	01Jan2000, 10:57	7.469
Subbasin-6	0.17	30.4	01Jan2000, 08:08	8.059
Subbasin-6	0.17	30.4	01Jan2000, 08:08	8.059

Project: Wood Hollow   Simulation Run: Future 100-year, 24-hour

Start of Run: 01Jan2000, 00:00
End of Run: 05Jan2000, 00:00
Compute Time: 21Jan2009, 13:27:51

Basin Model: Wood Hollow_Future_Mitigated
Meterologic Model 100-Year, 24-Hr, 2.75"
Control Specifications: Control 1

Volume Units: AC-FT

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (AC-FT)
Junction-1	1.86	50.2	01Jan2000, 16:47	42.635
Junction-10	5.5922	155.2	01Jan2000, 18:52	142.904
Junction-11	0.31	9.6	01Jan2000, 22:17	18.578
Junction-12	0.21	6.6	01Jan2000, 22:22	13.226
Junction-13	2.07	56	01Jan2000, 16:56	55.861
Junction-14	0.05	1.3	01Jan2000, 22:53	2.842
Junction-15	0.1	12.2	01Jan2000, 15:27	5.684
Junction-2	3.89	114.2	01Jan2000, 16:49	90.982
Junction-3	4.94	129.9	01Jan2000, 18:38	102.086
Junction-4	5.11	134.7	01Jan2000, 18:43	111.742
Junction-5	5.11	134.7	01Jan2000, 18:45	111.741
Junction-6	5.227	138.1	01Jan2000, 18:46	119.087
Junction-7	5.5472	154.1	01Jan2000, 18:44	141.513
Junction-8	5.5922	155.2	01Jan2000, 18:51	142.904
Junction-9	5.5922	155.2	01Jan2000, 18:51	142.904
Mountain View Corridor North	0.1981	29.7	01Jan2000, 15:14	13.874
Mountain View Corridor South	0.1221	18.7	01Jan2000, 15:04	8.552
Parry Farms	0.11	12.7	01Jan2000, 15:10	5.599
Parry Farms Detention Pond	5.7022	159.6	01Jan2000, 18:52	148.503
Power Plant	0.02	1.4	01Jan2000, 15:14	0.619
Provo-Reservoir	0.025	1.8	01Jan2000, 15:17	0.773
Provo-Reservoir Canal	5.5722	154.6	01Jan2000, 18:47	142.286
Reach-1	1.86	50.2	01Jan2000, 16:54	42.635
Reach-10	5.11	134.7	01Jan2000, 18:45	111.741
Reach-11	5.11	134.7	01Jan2000, 18:46	111.741
Reach-12	5.227	138.1	01Jan2000, 18:47	119.087
Reach-13	0.31	9.6	01Jan2000, 22:23	18.578

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (AC-FT)
Reach-14	0.21	6.6	01Jan2000, 22:34	13.226
Reach-15	2.07	56	01Jan2000, 17:04	55.861
Reach-16	0.05	1.3	01Jan2000, 22:56	2.842
Reach-17	0.1	12.2	01Jan2000, 15:27	5.684
Reach-2	3.89	114.2	01Jan2000, 18:40	90.979
Reach-3	4.94	129.9	01Jan2000, 18:42	102.086
Reach-4	5.5472	154.1	01Jan2000, 18:47	141.513
Reach-5	5.5722	154.6	01Jan2000, 18:50	142.286
Reach-6	5.5922	155.2	01Jan2000, 18:51	142.904
Reach-7	5.5922	155.2	01Jan2000, 18:51	142.904
Reach-8	5.5922	155.2	01Jan2000, 18:52	142.904
Reach-9	5.5922	155.2	01Jan2000, 18:53	142.904
Redwood Road	5.5922	155.2	01Jan2000, 18:50	142.904
Reservoir-1	0.31	9.6	01Jan2000, 22:17	18.578
Reservoir-2	0.21	6.6	01Jan2000, 22:22	13.226
Reservoir-3	0.05	1.3	01Jan2000, 22:53	2.842
Reservoir-4	0.17	5	01Jan2000, 22:34	9.656
Reservoir-5	0.025	0.5	01Jan2000, 22:06	0.773
Reservoir-6	0.02	0.6	01Jan2000, 19:09	0.619
Rosecrest/South Hills_1	0.1	12.2	01Jan2000, 15:27	5.684
Rosecrest/South Hills_2	0.017	3.5	01Jan2000, 14:35	1.668
Rosecrest/South Hills Deten	0.117	3.5	01Jan2000, 22:40	7.346
Subbasin-1	0.78	24.9	01Jan2000, 16:37	13.861
Subbasin-10	0.31	40.6	01Jan2000, 15:16	18.591
Subbasin-11	0.21	28.8	01Jan2000, 15:15	13.274
Subbasin-15	0.05	6.3	01Jan2000, 15:11	2.842
Subbasin-2	0.77	17	01Jan2000, 16:56	10.196
Subbasin-3	1.12	39.2	01Jan2000, 16:38	21.756
Subbasin-4	0.65	19.1	01Jan2000, 16:31	10.523
Subbasin-5	1.05	17.4	01Jan2000, 17:17	11.107
Subbasin-6	0.17	20.8	01Jan2000, 15:25	9.663
Subbasin-6	0.17	30.4	01Jan2000, 08:08	8.059

Appendix C

Temporal Storm Distribution Tabular Data

Farmer-Fletcher Temporal Distribution

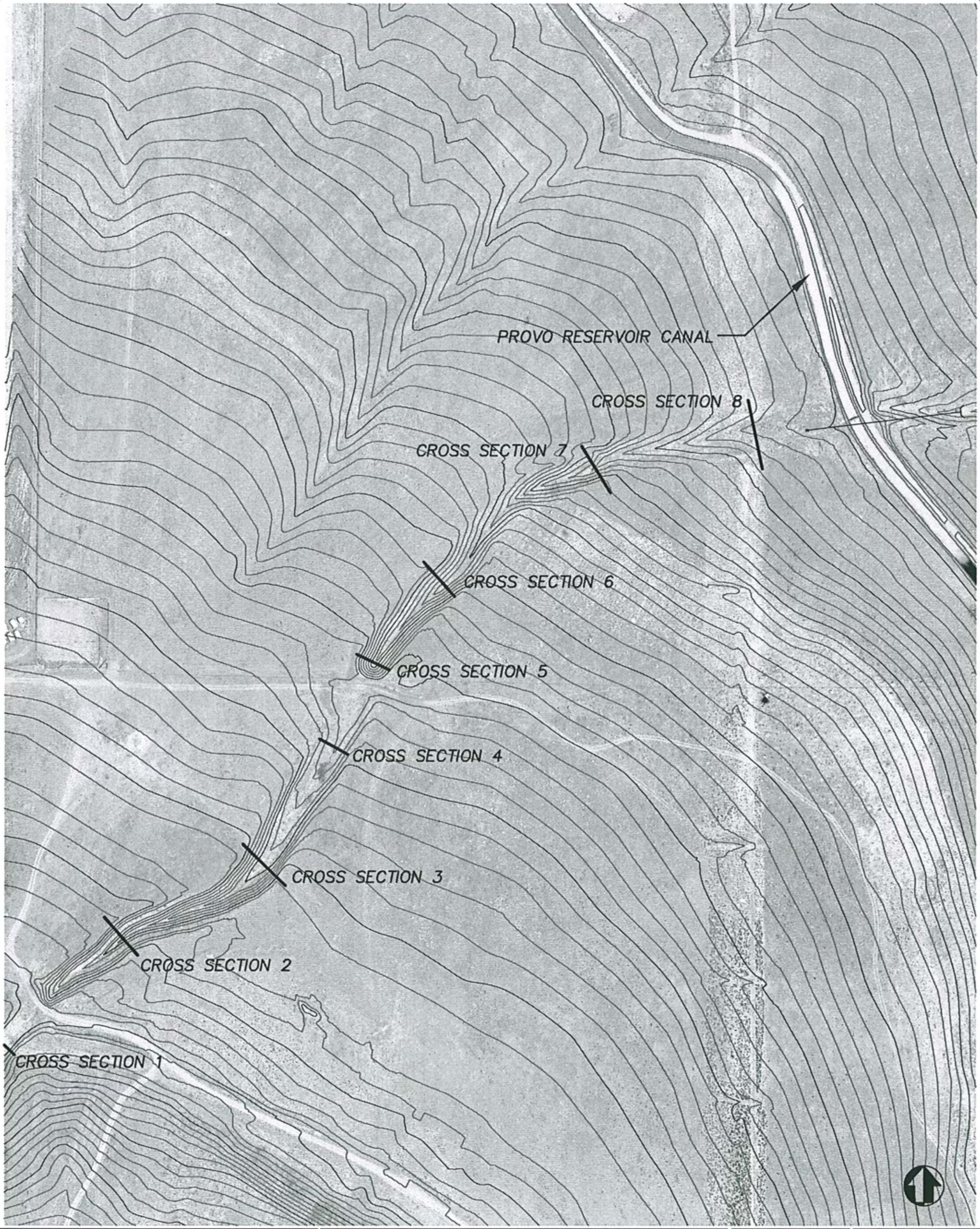
Farmer-Fletcher 1-Hour			Farmer-Fletcher 3-Hour			Farmer-Fletcher 6-Hour		
Time (%)	1 Hour	Cumulative Rainfall (%)	Time (%)	3 Hour	Cumulative Rainfall (%)	Time (%)	6 Hour	Cumulative Rainfall (%)
0.00	0	0	0.00	0	0	0.00	0	0
1.67	1	0	1.67	3	0	1.67	6	0
3.33	2	0	3.33	6	0	3.33	12	0
5.00	3	0.2	5.00	9	0.2	5.00	18	0.2
6.67	4	0.4	6.67	12	0.4	6.67	24	0.4
8.33	5	0.6	8.33	15	0.6	8.33	30	0.6
10.00	6	0.8	10.00	18	0.8	10.00	36	0.8
11.67	7	1	11.67	21	1	11.67	42	1
13.33	8	1.2	13.33	24	1.2	13.33	48	1.2
15.00	9	1.5	15.00	27	1.5	15.00	54	1.5
16.67	10	1.8	16.67	30	1.8	16.67	60	1.8
18.33	11	2.2	18.33	33	2.2	18.33	66	2.2
20.00	12	2.7	20.00	36	2.7	20.00	72	2.7
21.67	13	3.5	21.67	39	3.5	21.67	78	3.5
23.33	14	4.4	23.33	42	4.4	23.33	84	4.4
25.00	15	5.3	25.00	45	5.3	25.00	90	5.3
26.67	16	6.6	26.67	48	6.6	26.67	96	6.6
28.33	17	8.3	28.33	51	8.3	28.33	102	8.3
30.00	18	10.3	30.00	54	10.3	30.00	108	10.3
31.67	19	12.7	31.67	57	12.7	31.67	114	12.7
33.33	20	15.6	33.33	60	15.6	33.33	120	15.6
35.00	21	18.9	35.00	63	18.9	35.00	126	18.9
36.67	22	22.3	36.67	66	22.3	36.67	132	22.3
38.33	23	25.8	38.33	69	25.8	38.33	138	25.8
40.00	24	29.6	40.00	72	29.6	40.00	144	29.6
41.67	25	33.5	41.67	75	33.5	41.67	150	33.5
43.33	26	38	43.33	78	38	43.33	156	38
45.00	27	43.2	45.00	81	43.2	45.00	162	43.2
46.67	28	48.6	46.67	84	48.6	46.67	168	48.6
48.33	29	54	48.33	87	54	48.33	174	54
50.00	30	59.4	50.00	90	59.4	50.00	180	59.4
51.67	31	64.6	51.67	93	64.6	51.67	186	64.6
53.33	32	69.1	53.33	96	69.1	53.33	192	69.1
55.00	33	73.1	55.00	99	73.1	55.00	198	73.1
56.67	34	76.6	56.67	102	76.6	56.67	204	76.6
58.33	35	79.6	58.33	105	79.6	58.33	210	79.6
60.00	36	81.8	60.00	108	81.8	60.00	216	81.8
61.67	37	83.8	61.67	111	83.8	61.67	222	83.8
63.33	38	85.6	63.33	114	85.6	63.33	228	85.6
65.00	39	87.2	65.00	117	87.2	65.00	234	87.2
66.67	40	88.6	66.67	120	88.6	66.67	240	88.6
68.33	41	89.8	68.33	123	89.8	68.33	246	89.8
70.00	42	90.9	70.00	126	90.9	70.00	252	90.9
71.67	43	91.9	71.67	129	91.9	71.67	258	91.9
73.33	44	92.8	73.33	132	92.8	73.33	264	92.8
75.00	45	93.7	75.00	135	93.7	75.00	270	93.7
76.67	46	94.5	76.67	138	94.5	76.67	276	94.5
78.33	47	95.1	78.33	141	95.1	78.33	282	95.1
80.00	48	95.7	80.00	144	95.7	80.00	288	95.7
81.67	49	96.2	81.67	147	96.2	81.67	294	96.2
83.33	50	96.7	83.33	150	96.7	83.33	300	96.7
85.00	51	97.2	85.00	153	97.2	85.00	306	97.2
86.67	52	97.7	86.67	156	97.7	86.67	312	97.7
88.33	53	98.1	88.33	159	98.1	88.33	318	98.1
90.00	54	98.5	90.00	162	98.5	90.00	324	98.5
91.67	55	98.9	91.67	165	98.9	91.67	330	98.9
93.33	56	99.2	93.33	168	99.2	93.33	336	99.2
95.00	57	99.5	95.00	171	99.5	95.00	342	99.5
96.67	58	99.7	96.67	174	99.7	96.67	348	99.7
98.33	59	99.9	98.33	177	99.9	98.33	354	99.9
100.00	60	100	100.00	180	100	100.00	360	100

GBEA 12 and 24 Hour Temporal Distribution

GBEA 12-Hour			GBEA 24-Hour		
Cumulative Rainfall (%)	12-Hour	Time (%)	Cumulative Rainfall (%)	24-Hour	Time (%)
0.00	0	0.0	0.00	0	0.0
0.25	15	2.1	0.25	30	2.1
0.65	30	4.2	0.65	60	4.2
1.09	45	6.3	1.09	90	6.3
1.54	60	8.3	1.54	120	8.3
2.00	75	10.4	2.00	150	10.4
2.50	90	12.5	2.50	180	12.5
3.08	105	14.6	3.08	210	14.6
3.70	120	16.7	3.70	240	16.7
4.33	135	18.8	4.33	270	18.8
4.98	150	20.8	4.98	300	20.8
5.69	165	22.9	5.69	330	22.9
6.44	180	25.0	6.44	360	25.0
7.24	195	27.1	7.24	390	27.1
8.14	210	29.2	8.14	420	29.2
9.14	225	31.3	9.14	450	31.3
10.24	240	33.3	10.24	480	33.3
11.39	255	35.4	11.39	510	35.4
12.69	270	37.5	12.69	540	37.5
14.09	285	39.6	14.09	570	39.6
15.70	300	41.7	15.70	600	41.7
17.60	315	43.8	17.60	630	43.8
20.10	330	45.8	20.10	660	45.8
23.10	345	47.9	23.10	690	47.9
28.11	360	50.0	28.11	720	50.0
34.11	375	52.1	34.11	750	52.1
40.62	390	54.2	40.62	780	54.2
47.38	405	56.3	47.38	810	56.3
54.38	420	58.3	54.38	840	58.3
61.29	435	60.4	61.29	870	60.4
67.80	450	62.5	67.80	900	62.5
72.80	465	64.6	72.80	930	64.6
76.31	480	66.7	76.31	960	66.7
79.11	495	68.8	79.11	990	68.8
81.41	510	70.8	81.41	1020	70.8
83.51	525	72.9	83.51	1050	72.9
85.42	540	75.0	85.42	1080	75.0
87.22	555	77.1	87.22	1110	77.1
88.92	570	79.2	88.92	1140	79.2
90.47	585	81.3	90.47	1170	81.3
91.97	600	83.3	91.97	1200	83.3
93.42	615	85.4	93.42	1230	85.4
94.82	630	87.5	94.82	1260	87.5
96.13	645	89.6	96.13	1290	89.6
97.23	660	91.7	97.23	1320	91.7
98.23	675	93.8	98.23	1350	93.8
99.13	690	95.8	99.13	1380	95.8
99.56	705	97.9	99.56	1410	97.9
100.00	720	100.0	100.00	1440	100.0

Appendix D

Capacity Calculations for Natural Channel Upstream of Provo-Reservoir Canal



PSOMAS
4179 Riverboat Road, Suite 200
Salt Lake City, Utah 84123
(801) 270-5777 (801) 270-5782 (FAX)

WOOD HOLLOW
X-SECTIONS EXHIBIT
ABOVE PROVO RESERVOIR CANAL

Scale: NONE	PROJECT NO. 8SAL010500
Drawn by: JMB	FIGURE # —
Checked by: TM	

Worksheet for Cross Section 1

Project Description

Friction Method	Manning Formula
Solve For	Discharge

Input Data

Channel Slope	0.05460	ft/ft
Normal Depth	5.59	ft

Section Definitions

Station (ft)	Elevation (ft)
0+00	4815.02
0+12	4809.64
0+30	4808.43
0+41	4809.64
0+58	4815.20

Roughness Segment Definitions

Start Station	Ending Station	Roughness Coefficient
(0+00, 4815.02)	(0+58, 4815.20)	0.060

Results

Discharge	2687.60	ft^3/s
Elevation Range	4808.43 to 4815.20 ft	
Flow Area	195.97	ft^2
Wetted Perimeter	53.72	ft
Top Width	51.94	ft
Normal Depth	5.59	ft
Critical Depth	6.25	ft
Critical Slope	0.03416	ft/ft
Velocity	13.71	ft/s
Velocity Head	2.92	ft
Specific Energy	8.51	ft
Froude Number	1.24	
Flow Type	Supercritical	

Worksheet for Cross Section 1

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	5.59	ft
Critical Depth	6.25	ft
Channel Slope	0.05460	ft/ft
Critical Slope	0.03416	ft/ft

Messages

Notes

Assume 1' Freeboard for this x-section

Cross Section for Cross Section 1

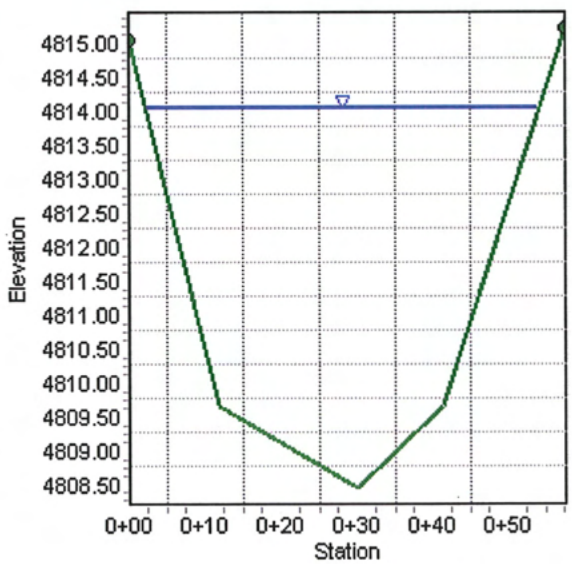
Project Description

Friction Method	Manning Formula
Solve For	Discharge

Input Data

Channel Slope	0.05460	ft/ft
Normal Depth	5.59	ft
Discharge	2687.60	ft³/s

Cross Section Image



Worksheet for Cross Section 2

Project Description

Friction Method	Manning Formula
Solve For	Discharge

Input Data

Channel Slope	0.03300	ft/ft
Normal Depth	13.00	ft
Section Definitions		

Station (ft)	Elevation (ft)
0+00	4802.38
0+21	4801.84
0+51	4787.30
0+73	4800.84
0+94	4801.30

Roughness Segment Definitions

Start Station	Ending Station	Roughness Coefficient
(0+00, 4802.38)	(0+94, 4801.30)	0.060

Results

Discharge	4505.44	ft^3/s
Elevation Range	4787.30 to 4802.38 ft	
Flow Area	313.25	ft^2
Wetted Perimeter	54.80	ft
Top Width	48.19	ft
Normal Depth	13.00	ft
Critical Depth	12.97	ft
Critical Slope	0.03339	ft/ft
Velocity	14.38	ft/s
Velocity Head	3.21	ft
Specific Energy	16.21	ft
Froude Number	0.99	
Flow Type	Subcritical	

Worksheet for Cross Section 2

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	13.00	ft
Critical Depth	12.97	ft
Channel Slope	0.03300	ft/ft
Critical Slope	0.03339	ft/ft

Messages

Notes

Assume 1' freeboard for this x-section

Cross Section for Cross Section 2

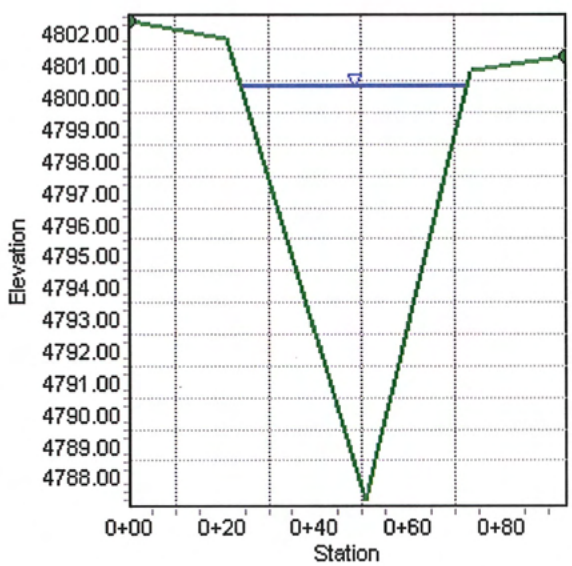
Project Description

Friction Method	Manning Formula
Solve For	Discharge

Input Data

Channel Slope	0.03300	ft/ft
Normal Depth	13.00	ft
Discharge	4505.44	ft³/s

Cross Section Image



Worksheet for Cross Section 3

Project Description

Friction Method	Manning Formula
Solve For	Discharge

Input Data

Channel Slope	0.01550	ft/ft
Normal Depth	11.54	ft

Section Definitions

Station (ft)	Elevation (ft)
0+00	4790.08
0+22	4789.72
0+42	4779.82
0+53	4777.54
0+66	4780.14
0+84	4790.93
1+09	4791.26

Roughness Segment Definitions

Start Station	Ending Station	Roughness Coefficient
(0+00, 4790.08)	(1+09, 4791.26)	0.060

Results

Discharge	4193.54	ft^3/s
Elevation Range	4777.54 to 4791.26 ft	
Flow Area	397.83	ft^2
Wetted Perimeter	62.93	ft
Top Width	57.91	ft
Normal Depth	11.54	ft
Critical Depth	9.82	ft
Critical Slope	0.03218	ft/ft
Velocity	10.54	ft/s
Velocity Head	1.73	ft
Specific Energy	13.27	ft

Worksheet for Cross Section 3

Results

Froude Number		0.71	
Flow Type	Subcritical		

GVF Input Data

Downstream Depth		0.00	ft
Length		0.00	ft
Number Of Steps		0	

GVF Output Data

Upstream Depth		0.00	ft
Profile Description			
Profile Headloss		0.00	ft
Downstream Velocity		Infinity	ft/s
Upstream Velocity		Infinity	ft/s
Normal Depth		11.54	ft
Critical Depth		9.82	ft
Channel Slope		0.01550	ft/ft
Critical Slope		0.03218	ft/ft

Cross Section for Cross Section 3

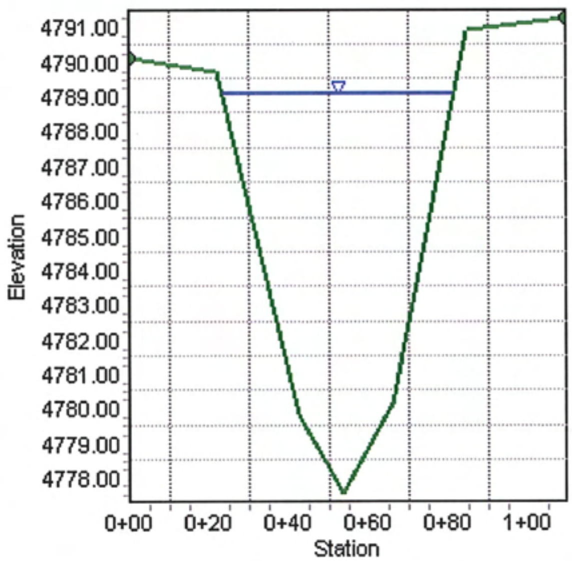
Project Description

Friction Method	Manning Formula
Solve For	Discharge

Input Data

Channel Slope	0.01550	ft/ft
Normal Depth	11.54	ft
Discharge	4193.54	ft^3/s

Cross Section Image



Worksheet for Cross Section 4

Project Description

Friction Method	Manning Formula
Solve For	Discharge

Input Data

Channel Slope	0.03232	ft/ft
Normal Depth	2.86	ft
Section Definitions		

Station (ft)	Elevation (ft)
0+00	4777.13
0+10	4773.27
0+29	4773.61
0+46	4773.29
0+58	4778.50

Roughness Segment Definitions

Start Station	Ending Station	Roughness Coefficient
(0+00, 4777.13)	(0+58, 4778.50)	0.060

Results

Discharge	891.73	ft^3/s
Elevation Range	4773.27 to 4778.50 ft	
Flow Area	115.64	ft^2
Wetted Perimeter	50.72	ft
Top Width	49.59	ft
Normal Depth	2.86	ft
Critical Depth	2.67	ft
Critical Slope	0.04160	ft/ft
Velocity	7.71	ft/s
Velocity Head	0.92	ft
Specific Energy	3.78	ft
Froude Number	0.89	
Flow Type	Subcritical	

Worksheet for Cross Section 4

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	2.86	ft
Critical Depth	2.67	ft
Channel Slope	0.03232	ft/ft
Critical Slope	0.04160	ft/ft

Messages

Notes

Assume 1' Freeboard for this x-section

Cross Section for Cross Section 4

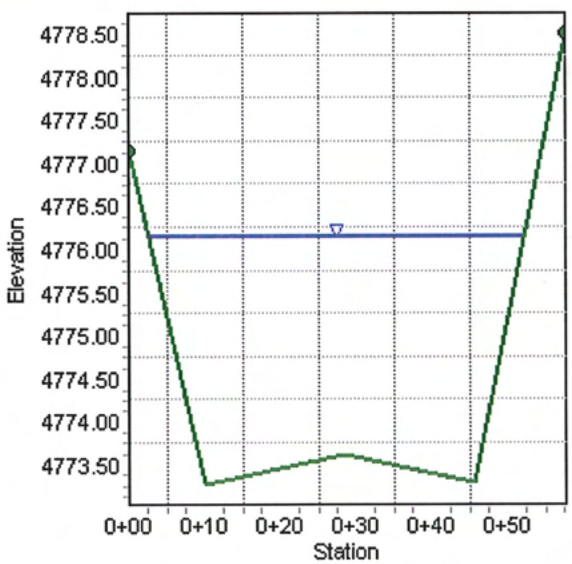
Project Description

Friction Method	Manning Formula
Solve For	Discharge

Input Data

Channel Slope	0.03232	ft/ft
Normal Depth	2.86	ft
Discharge	891.73	ft³/s

Cross Section Image



Worksheet for Cross Section 5

Project Description

Friction Method	Manning Formula
Solve For	Discharge

Input Data

Channel Slope	0.02847	ft/ft
Normal Depth	11.67	ft
Section Definitions		

Station (ft)	Elevation (ft)
0+00	4771.21
0+05	4771.12
0+09	4771.01
0+35	4758.56
0+38	4758.34
0+46	4760.88
0+49	4762.22
0+52	4763.77
0+55	4765.86
0+68	4771.01

Roughness Segment Definitions

Start Station	Ending Station	Roughness Coefficient
(0+00, 4771.21)	(0+68, 4771.01)	0.060

Results

Discharge	4591.46	ft^3/s
Elevation Range	4758.34 to 4771.21 ft	
Flow Area	342.80	ft^2
Wetted Perimeter	59.74	ft
Top Width	54.66	ft
Normal Depth	11.67	ft
Critical Depth	11.38	ft
Critical Slope	0.03227	ft/ft

Worksheet for Cross Section 5

Results

Velocity		13.39	ft/s
Velocity Head		2.79	ft
Specific Energy		14.46	ft
Froude Number		0.94	
Flow Type	Subcritical		

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	11.67	ft
Critical Depth	11.38	ft
Channel Slope	0.02847	ft/ft
Critical Slope	0.03227	ft/ft

Messages

Notes

Assume 1' Freeboard for this x-section

Cross Section for Cross Section 5

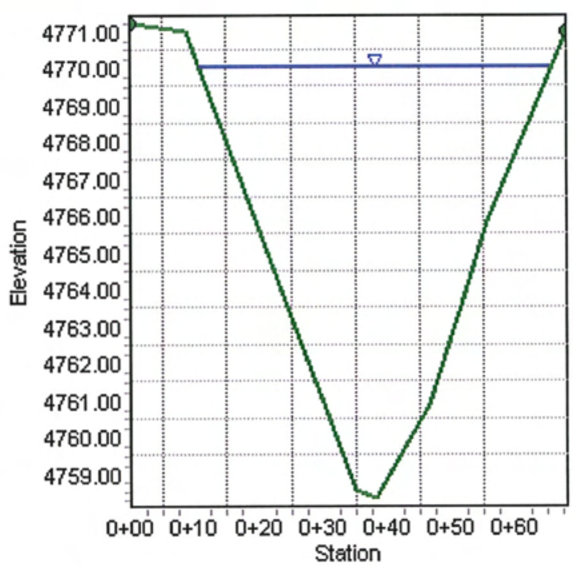
Project Description

Friction Method	Manning Formula
Solve For	Discharge

Input Data

Channel Slope	0.02847	ft/ft
Normal Depth	11.67	ft
Discharge	4591.46	ft³/s

Cross Section Image



Worksheet for Cross Section 6

Project Description

Friction Method	Manning Formula
Solve For	Discharge

Input Data

Channel Slope	0.02074	ft/ft
Normal Depth	9.92	ft
Section Definitions		

Station (ft)	Elevation (ft)
0+00	4761.47
0+09	4758.51
0+22	4751.61
0+32	4750.55
0+37	4751.32
0+41	4752.87
0+44	4754.97
0+47	4756.11
0+49	4758.09
0+59	4762.23

Roughness Segment Definitions

Start Station	Ending Station	Roughness Coefficient
(0+00, 4761.47)	(0+59, 4762.23)	0.060

Results

Discharge	3261.40	ft^3/s
Elevation Range	4750.55 to 4762.23 ft	
Flow Area	299.40	ft^2
Wetted Perimeter	56.09	ft
Top Width	51.59	ft
Normal Depth	9.92	ft
Critical Depth	8.86	ft
Critical Slope	0.03353	ft/ft

Worksheet for Cross Section 6

Results

Velocity		10.89	ft/s
Velocity Head		1.84	ft
Specific Energy		11.76	ft
Froude Number		0.80	
Flow Type	Subcritical		

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	9.92	ft
Critical Depth	8.86	ft
Channel Slope	0.02074	ft/ft
Critical Slope	0.03353	ft/ft

Messages

Notes

Assume 1' Freeboard for this x-section

Cross Section for Cross Section 6

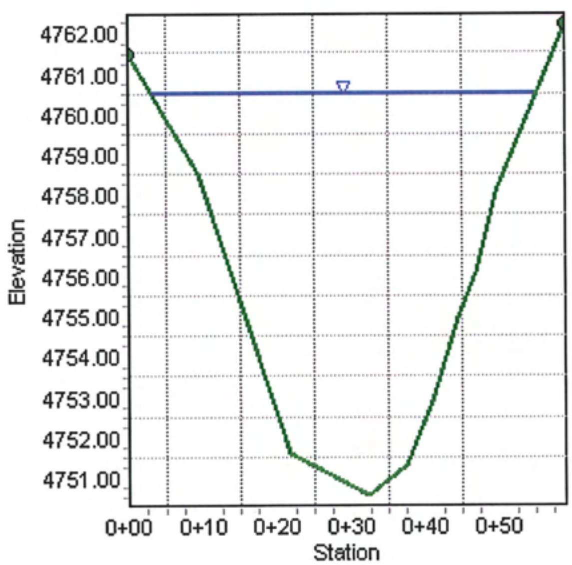
Project Description

Friction Method	Manning Formula
Solve For	Discharge

Input Data

Channel Slope	0.02074	ft/ft
Normal Depth	9.92	ft
Discharge	3261.40	ft³/s

Cross Section Image



Worksheet for Cross Section 7

Project Description

Friction Method	Manning Formula
Solve For	Discharge

Input Data

Channel Slope	0.03890	ft/ft
Normal Depth	6.63	ft
Section Definitions		

Station (ft)	Elevation (ft)
0+00	4741.25
0+20	4739.79
0+33	4734.96
0+43	4734.94
0+52	4733.62
0+54	4734.91
0+57	4735.69
0+65	4740.86
0+74	4741.99
0+98	4741.88

Roughness Segment Definitions

Start Station	Ending Station	Roughness Coefficient
(0+00, 4741.25)	(0+98, 4741.88)	0.060

Results

Discharge	2121.39	ft³/s
Elevation Range	4733.62 to 4741.99 ft	
Flow Area	186.76	ft²
Wetted Perimeter	52.66	ft
Top Width	49.92	ft
Normal Depth	6.63	ft
Critical Depth	6.77	ft
Critical Slope	0.03629	ft/ft

Worksheet for Cross Section 7

Results

Velocity		11.36	ft/s
Velocity Head		2.01	ft
Specific Energy		8.64	ft
Froude Number		1.04	
Flow Type	Supercritical		

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	6.63	ft
Critical Depth	6.77	ft
Channel Slope	0.03890	ft/ft
Critical Slope	0.03629	ft/ft

Cross Section for Cross Section 7

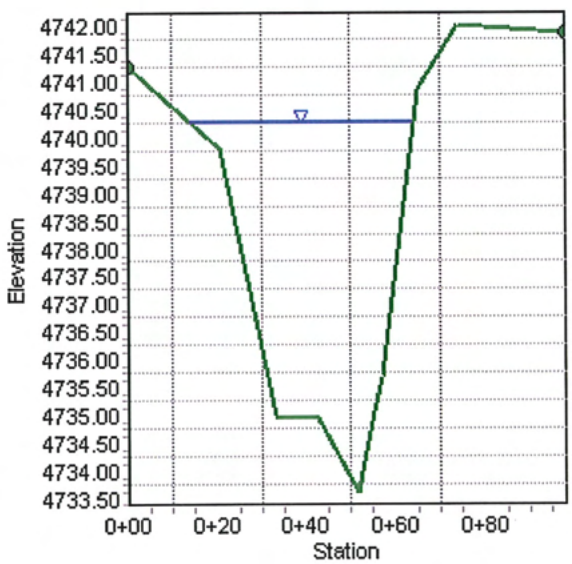
Project Description

Friction Method	Manning Formula
Solve For	Discharge

Input Data

Channel Slope	0.03890	ft/ft
Normal Depth	6.63	ft
Discharge	2121.39	ft³/s

Cross Section Image



Worksheet for Cross Section 8

Project Description

Friction Method	Manning Formula
Solve For	Discharge

Input Data

Channel Slope	0.02890	ft/ft
Normal Depth	3.74	ft

Section Definitions

Station (ft)	Elevation (ft)
0+25	4727.22
0+36	4722.99
0+43	4722.39
0+56	4722.74
0+72	4723.23
1+03	4726.50
1+29	4727.13

Roughness Segment Definitions

Start Station	Ending Station	Roughness Coefficient
(0+25, 4727.22)	(1+29, 4727.13)	0.060

Results

Discharge	1311.21	ft^3/s
Elevation Range	4722.39 to 4727.22 ft	
Flow Area	174.39	ft^2
Wetted Perimeter	73.07	ft
Top Width	72.32	ft
Normal Depth	3.74	ft
Critical Depth	3.46	ft
Critical Slope	0.04061	ft/ft
Velocity	7.52	ft/s
Velocity Head	0.88	ft
Specific Energy	4.62	ft

Worksheet for Cross Section 8

Results

Froude Number		0.85	
Flow Type	Subcritical		

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	3.74	ft
Critical Depth	3.46	ft
Channel Slope	0.02890	ft/ft
Critical Slope	0.04061	ft/ft

Cross Section for Cross Section 8

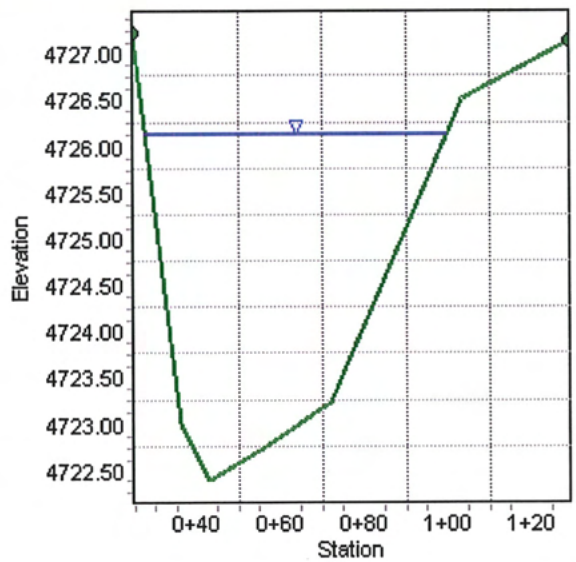
Project Description

Friction Method	Manning Formula
Solve For	Discharge

Input Data

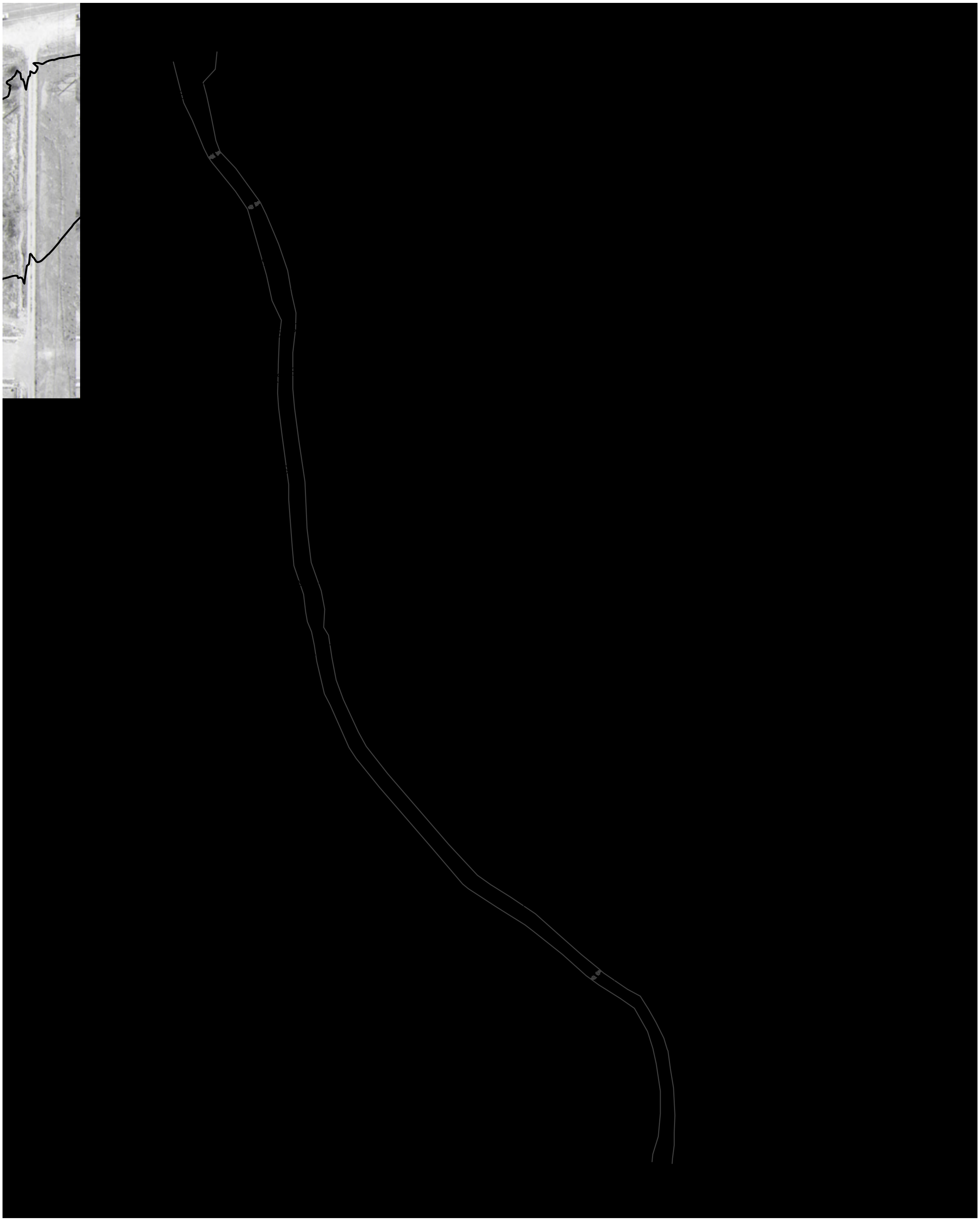
Channel Slope	0.02890	ft/ft
Normal Depth	3.74	ft
Discharge	1311.21	ft³/s

Cross Section Image



Appendix E

Capacity Calculations for the Natural and Improved Channel Downstream of the Provo-Reservoir Canal



P S O M A S

4179 Riverboat Road, Suite 200
Salt Lake City, Utah 84123
(801) 270-5777 (801) 270-5782 (FAX)

WOOD HOLLOW

X-SECTIONS EXHIBIT

BELOW PROVO RESERVOIR CANAL

Scale:	NONE
Drawn by:	JMB
Checked by:	TM
PROJECT NO.	8SAL010500
FIGURE #	—

Safe Capacity Analysis for Existing Open Channel Between Provo Reservoir Canal and Redwood Rd

Governing safe capacity = 4.9 cfs

- Governing Cross Section

			Maximum flow (cfs) within safe capacity for the n = 0.060 model is									18.2
River Sta	**Breach El**	**Minimum Channel El**	**Water Surface El**	**Normal Depth (y_i)**	**Froude #**	**Sequent Depth (y_s)**	**Sequent WS El**	**Critial WS El**	**Vel Chnl**	**Existing Freeboard**	**Required Freeboard**	**Requirement Met**
ft	ft	ft	ft	ft		ft	ft	ft	(ft/s)	ft	ft	
1675.87	4710.51	4706.49	4707.49	1.00	0.69	NA	NA	4707.35	3.18	3.02	0.60	YES
1535.04	4705.85	4701.70	4702.57	0.87	0.80	NA	NA	4702.50	3.24	3.28	0.60	YES
1446.36	4702.08	4698.77	4699.60	0.83	0.66	NA	NA	4699.60	3.07	2.48	0.60	YES
1290.66	4694.45	4692.40	4693.42	1.02	0.96	NA	NA	4693.42	4.31	1.03	0.63	YES
848.22	4677.18	4674.08	4675.34	1.26	0.88	NA	NA	4675.27	3.98	1.84	0.62	YES
761.88	4673.9	4670.27	4671.56	1.29	0.78	NA	NA	4671.44	3.71	2.34	0.62	YES
617.21	4665.46	4663.48	4664.48	1.00	0.98	NA	NA	4664.47	4.08	0.98	0.63	YES
461.17	4659.32	4656.64	4657.26	0.62	0.70	NA	NA	4657.18	2.28	2.06	0.57	YES
400.03	4655.6	4653.76	4654.46	0.70	0.82	NA	NA	4654.41	2.76	1.14	0.59	YES
374.89	4653.43	4652.30	4652.83	0.53	1.01	NA	NA	4652.83	3.18	0.60	0.60	YES
340.30	4652.15	4648.01	4648.81	0.80	1.41	1.24	4649.25	4648.92	5.13	2.90	0.66	YES
89.71	4642.49	4637.86	4638.58	0.72	0.85	NA	NA	4638.53	3.73	3.91	0.62	YES
38.40	4639.65	4636.09	4636.74	0.65	0.64	NA	NA	4636.64	2.08	2.91	0.56	YES

			Maximum flow (cfs) within safe capacity for the n = 0.035 model is									4.9
River Sta	**Breach El**	**Minimum Channel El**	**Water Surface El**	**Normal Depth (y_i)**	**Froude #**	**Sequent Depth (y_s)**	**Sequent WS El**	**Critial WS El**	**Vel Chnl**	**Existing Freeboard**	**Required Freeboard**	**Requirement Met**
ft	ft	ft	ft	ft		ft	ft	ft	(ft/s)	ft	ft	
1675.87	4710.51	4706.49	4707.01	0.52	0.99	NA	NA	4707.01	2.88	3.50	0.59	YES
1535.04	4705.85	4701.70	4702.15	0.45	1.20	0.57	4702.27	4702.19	3.21	3.58	0.60	YES
1446.36	4702.08	4698.77	4699.06	0.29	1.00	NA	NA	4699.06	2.85	3.02	0.59	YES
1290.66	4694.45	4692.40	4692.94	0.54	1.35	0.80	4693.20	4693.01	4.00	1.25	0.62	YES
848.22	4677.18	4674.08	4674.76	0.68	1.10	0.77	4674.85	4674.79	3.64	2.33	0.61	YES
761.88	4673.9	4670.27	4670.88	0.61	1.45	0.98	4671.25	4670.97	4.52	2.65	0.64	YES
617.21	4665.46	4663.48	4664.01	0.53	1.18	0.66	4664.14	4664.05	3.56	1.32	0.61	YES
461.17	4659.32	4656.64	4656.93	0.29	1.28	0.40	4657.04	4656.96	2.77	2.28	0.59	YES
400.03	4655.6	4653.76	4654.13	0.37	1.06	0.40	4654.16	4654.15	2.61	1.44	0.58	YES
374.89	4653.43	4652.30	4652.55	0.25	1.79	0.52	4652.82	4652.62	3.61	0.61	0.61	YES
340.30	4652.15	4648.01	4648.44	0.43	1.86	0.94	4648.95	4648.55	4.87	3.20	0.65	YES
89.71	4642.49	4637.86	4638.22	0.36	0.99	NA	NA	4638.22	2.71	4.27	0.58	YES
38.40	4639.65	4636.09	4636.39	0.30	1.18	0.37	4636.46	4636.42	2.60	3.19	0.58	YES

Total Capacity Analysis for Existing Open Channel Between Provo Reservoir Canal and Redwood Rd

Governing total capacity = **30.9** cfs — - Governing Cross Section

			Maximum flow (cfs) within total capacity for the n = 0.060 model is									85.1
River Sta	**Breach El**	**Minimum Channel El**	**Water Surface El**	**Normal Depth (y_i)**	**Froude #**	**Sequent Depth (y_s)**	**Sequent WS El**	**Critial WS El**	**Vel Chnl**	**Existing Freeboard**	**Required Freeboard**	**Requirement Met**
ft	ft	ft	ft	ft		ft	ft	ft	(ft/s)	ft	ft	
1675.87	4710.51	4706.49	4708.22	1.73	0.91	NA	NA	4708.22	NA	2.29	0.00	YES
1535.04	4705.85	4701.70	4703.44	1.74	0.71	NA	NA	4703.26	NA	2.41	0.00	YES
1446.36	4702.08	4698.77	4700.48	1.71	0.89	NA	NA	4700.37	NA	1.60	0.00	YES
1290.66	4694.45	4692.40	4694.38	1.98	0.88	NA	NA	4694.38	NA	0.07	0.00	YES
848.22	4677.18	4674.08	4676.28	2.20	0.95	2.05	4676.13	4676.30	NA	1.05	0.00	YES
761.88	4673.9	4670.27	4672.47	2.20	0.94	2.02	4672.29	4672.51	NA	1.61	0.00	YES
617.21	4665.46	4663.48	4665.36	1.88	1.04	1.98	4665.46	4665.38	NA	0.00	0.00	YES
461.17	4659.32	4656.64	4657.76	1.12	0.74	NA	NA	4657.65	NA	1.56	0.00	YES
400.03	4655.6	4653.76	4654.96	1.20	1.00	NA	NA	4654.96	NA	0.64	0.00	YES
374.89	4653.43	4652.30	4653.37	1.07	1.01	NA	NA	4653.37	NA	0.06	0.00	YES
340.30	4652.15	4648.01	4649.47	1.46	1.54	2.53	4650.54	4649.76	NA	1.61	0.00	YES
89.71	4642.49	4637.86	4639.38	1.52	0.94	NA	NA	4639.38	NA	3.11	0.00	YES
38.40	4639.65	4636.09	4637.22	1.13	0.73	NA	NA	4637.09	NA	2.43	0.00	YES

			Maximum flow (cfs) within total capacity for the n = 0.035 model is									30.9
River Sta	**Breach El**	**Minimum Channel El**	**Water Surface El**	**Normal Depth (y_i)**	**Froude #**	**Sequent Depth (y_s)**	**Sequent WS El**	**Critial WS El**	**Vel Chnl**	**Existing Freeboard**	**Required Freeboard**	**Requirement Met**
ft	ft	ft	ft	ft		ft	ft	ft	(ft/s)	ft	ft	
1675.87	4710.51	4706.49	4707.44	0.95	1.31	1.35	4707.84	4707.58	NA	2.67	0.00	YES
1535.04	4705.85	4701.70	4702.60	0.90	1.23	1.18	4702.88	4702.69	NA	2.97	0.00	YES
1446.36	4702.08	4698.77	4699.55	0.78	1.24	1.03	4699.80	4699.65	NA	2.28	0.00	YES
1290.66	4694.45	4692.40	4693.48	1.08	1.42	1.70	4694.10	4693.69	NA	0.35	0.00	YES
848.22	4677.18	4674.08	4675.40	1.32	1.34	1.93	4676.01	4675.56	NA	1.17	0.00	YES
761.88	4673.9	4670.27	4671.51	1.24	1.47	2.03	4672.30	4671.72	NA	1.60	0.00	YES
617.21	4665.46	4663.48	4664.53	1.05	1.49	1.75	4665.23	4664.72	NA	0.23	0.00	YES
461.17	4659.32	4656.64	4657.23	0.59	1.35	0.87	4657.51	4657.30	NA	1.81	0.00	YES
400.03	4655.6	4653.76	4654.50	0.74	1.23	0.97	4654.73	4654.55	NA	0.87	0.00	YES
374.89	4653.43	4652.30	4652.82	0.52	1.86	1.13	4653.43	4652.97	NA	0.00	0.00	YES
340.30	4652.15	4648.01	4648.86	0.85	2.07	2.10	4650.11	4649.15	NA	2.04	0.00	YES
89.71	4642.49	4637.86	4638.70	0.84	1.07	0.92	4638.78	4638.75	NA	3.71	0.00	YES
38.40	4639.65	4636.09	4636.63	0.54	1.75	1.09	4637.18	4636.76	NA	2.47	0.00	YES

HEC-RAS Plan: 060_safe River: Wood_Hollow Reach: Lower Profile: PF 1

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Lower	1675.87	PF 1	18.20	4706.49	4707.49	4707.35	4707.64	0.029168	3.18	5.96	10.86	0.69
Lower	1535.04	PF 1	18.20	4701.70	4702.57	4702.50	4702.73	0.042374	3.24	5.70	12.42	0.80
Lower	1446.36	PF 1	18.20	4698.77	4699.60		4699.75	0.027446	3.07	5.93	8.73	0.66
Lower	1290.66	PF 1	18.20	4692.40	4693.42	4693.42	4693.71	0.058405	4.31	4.38	8.55	0.96
Lower	848.22	PF 1	18.20	4674.08	4675.34	4675.27	4675.59	0.051657	3.98	4.57	7.26	0.88
Lower	761.88	PF 1	18.20	4670.27	4671.56	4671.44	4671.78	0.038064	3.71	4.94	7.65	0.78
Lower	617.21	PF 1	18.20	4663.48	4664.48	4664.47	4664.74	0.064300	4.08	4.46	8.24	0.98
Lower	461.17	PF 1	18.20	4656.64	4657.26	4657.18	4657.34	0.037214	2.28	8.03	25.64	0.70
Lower	400.03	PF 1	18.20	4653.76	4654.46	4654.41	4654.58	0.050574	2.76	6.59	18.83	0.82
Lower	374.89	PF 1	18.20	4652.30	4652.83	4652.83	4652.99	0.080518	3.18	5.73	18.80	1.01
Lower	340.3	PF 1	18.20	4648.01	4648.81	4648.92	4649.22	0.142432	5.13	3.55	8.58	1.41
Lower	89.71	PF 1	18.20	4637.86	4638.58	4638.53	4638.78	0.045478	3.73	5.20	10.41	0.85
Lower	38.4	PF 1	18.20	4636.09	4636.74	4636.64	4636.81	0.031378	2.08	8.74	26.69	0.64

HEC-RAS Plan: 035_safe River: Wood_Hollow Reach: Lower Profile: PF 1

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Lower	1675.87	PF 1	4.90	4706.49	4707.01	4707.01	4707.14	0.028129	2.88	1.70	6.53	0.99
Lower	1535.04	PF 1	4.90	4701.70	4702.15	4702.19	4702.31	0.042863	3.21	1.53	6.85	1.20
Lower	1446.36	PF 1	4.90	4698.77	4699.06	4699.06	4699.18	0.029411	2.85	1.72	6.87	1.00
Lower	1290.66	PF 1	4.90	4692.40	4692.94	4693.01	4693.19	0.052439	4.00	1.23	4.52	1.35
Lower	848.22	PF 1	4.90	4674.08	4674.76	4674.79	4674.97	0.033133	3.64	1.35	3.94	1.10
Lower	761.88	PF 1	4.90	4670.27	4670.88	4670.97	4671.19	0.059830	4.52	1.09	3.58	1.45
Lower	617.21	PF 1	4.90	4663.48	4664.01	4664.05	4664.21	0.039408	3.56	1.38	4.91	1.18
Lower	461.17	PF 1	4.90	4656.64	4656.93	4656.96	4657.05	0.056126	2.77	1.77	12.22	1.28
Lower	400.03	PF 1	4.90	4653.76	4654.13	4654.15	4654.24	0.035350	2.61	1.88	10.06	1.06
Lower	374.89	PF 1	4.90	4652.30	4652.55	4652.62	4652.75	0.114973	3.61	1.36	10.80	1.79
Lower	340.3	PF 1	4.90	4648.01	4648.44	4648.55	4648.80	0.106242	4.87	1.01	4.73	1.86
Lower	89.71	PF 1	4.90	4637.86	4638.22	4638.22	4638.33	0.028286	2.71	1.84	8.26	0.99
Lower	38.4	PF 1	4.90	4636.09	4636.39	4636.42	4636.50	0.046318	2.60	1.89	12.42	1.18

HEC-RAS Plan: 060_total River: Wood_Hollow Reach: Lower Profile: PF 1

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Lower	1675.87	PF 1	85.10	4706.49	4708.22	4708.22	4708.74	0.039530	6.10	16.00	16.40	0.91
Lower	1535.04	PF 1	85.10	4701.70	4703.44	4703.26	4703.75	0.024094	4.74	20.69	21.95	0.71
Lower	1446.36	PF 1	85.10	4698.77	4700.48	4700.37	4700.98	0.042144	5.69	14.96	11.76	0.89
Lower	1290.66	PF 1	85.10	4692.40	4694.38	4694.38	4694.89	0.036451	6.30	16.33	16.52	0.88
Lower	848.22	PF 1	85.10	4674.08	4676.28	4676.30	4676.91	0.045604	6.48	13.94	12.68	0.95
Lower	761.88	PF 1	85.10	4670.27	4672.47	4672.51	4673.11	0.042379	6.77	14.26	13.00	0.94
Lower	617.21	PF 1	85.10	4663.48	4665.36	4665.38	4665.90	0.059041	5.87	14.49	14.52	1.04
Lower	461.17	PF 1	85.10	4656.64	4657.76	4657.65	4657.97	0.030422	3.82	24.47	39.49	0.74
Lower	400.03	PF 1	85.10	4653.76	4654.96	4654.96	4655.26	0.062986	4.41	19.31	32.22	1.00
Lower	374.89	PF 1	85.10	4652.30	4653.37	4653.37	4653.69	0.062516	4.53	18.77	29.84	1.01
Lower	340.3	PF 1	85.10	4648.01	4649.47	4649.76	4650.45	0.137120	7.97	10.68	12.84	1.54
Lower	89.71	PF 1	85.10	4637.86	4639.38	4639.38	4639.92	0.041742	6.33	15.55	15.22	0.94
Lower	38.4	PF 1	85.10	4636.09	4637.22	4637.09	4637.42	0.031333	3.57	24.22	35.40	0.73

HEC-RAS Plan: 035_total River: Wood_Hollow Reach: Lower Profile: PF 1

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Lower	1675.87	PF 1	30.90	4706.49	4707.44	4707.58	4707.96	0.036658	5.83	5.48	10.52	1.31
Lower	1535.04	PF 1	30.90	4701.70	4702.60	4702.69	4703.01	0.033304	5.14	6.13	12.80	1.23
Lower	1446.36	PF 1	30.90	4698.77	4699.55	4699.65	4700.04	0.033687	5.62	5.50	8.55	1.24
Lower	1290.66	PF 1	30.90	4692.40	4693.48	4693.69	4694.15	0.042370	6.66	4.87	9.01	1.42
Lower	848.22	PF 1	30.90	4674.08	4675.40	4675.56	4675.99	0.039877	6.17	5.01	7.60	1.34
Lower	761.88	PF 1	30.90	4670.27	4671.51	4671.72	4672.23	0.047573	6.79	4.57	7.36	1.47
Lower	617.21	PF 1	30.90	4663.48	4664.53	4664.72	4665.15	0.049920	6.36	4.86	8.58	1.49
Lower	461.17	PF 1	30.90	4656.64	4657.23	4657.30	4657.51	0.048812	4.22	7.34	24.88	1.35
Lower	400.03	PF 1	30.90	4653.76	4654.50	4654.55	4654.78	0.037797	4.23	7.30	19.81	1.23
Lower	374.89	PF 1	30.90	4652.30	4652.82	4652.97	4653.32	0.093621	5.72	5.40	16.44	1.86
Lower	340.3	PF 1	30.90	4648.01	4648.86	4649.15	4649.80	0.102478	7.79	3.97	6.97	2.07
Lower	89.71	PF 1	30.90	4637.86	4638.70	4638.75	4639.08	0.022817	5.13	6.52	11.14	1.07
Lower	38.4	PF 1	30.90	4636.09	4636.63	4636.76	4637.04	0.084305	5.15	5.99	22.14	1.75

Appendix F
Iron Horse Storm Drain Capacity Calculations

Overall System Analysis

Inlets

Label	Hydraulic Grade In (ft)	Hydraulic Grade Out (ft)	Elevation (Ground) (ft)	Distance from Ground to HGL
CB 9+53.60	4,633.14	4,632.10	4,633.60	0.46
CB 10+10.00	4,631.44	4,629.28	4,632.22	0.78
CB 13+59.72	4,617.57	4,615.41	4,618.90	1.33
CB 17+01.49	4,603.90	4,602.79	4,608.04	4.14
CB 18+53.98	4,598.12	4,596.90	4,602.47	4.35
CB 21+30.28	4,593.25	4,592.14	4,594.73	1.48
CB 24+62.71	4,584.71	4,583.62	4,584.90	**0.19**
CB 25+24.14	4,582.94	4,581.63	4,584.52	1.58
CB 32+45.62	4,539.63	4,538.95	4,541.11	1.48
CB 33+92.85	4,535.79	4,535.14	4,545.00	9.21
CB 35+21.82	4,534.51	4,533.89	4,546.02	11.51
CB 36+82.48	4,532.78	4,532.14	4,541.21	8.43
CB 39+62.84	4,527.72	4,527.07	4,530.83	3.11
CB 41+22.78	4,514.37	4,513.73	4,517.49	3.12
CB 42+58.82	4,509.16	4,508.54	4,512.30	3.14
CB 48+71.21	4,479.79	4,479.04	4,493.76	13.97
CB 50+89.59	4,476.39	4,475.74	4,482.47	6.08
CB 51+62.84	4,475.39	4,474.74	4,479.83	4.44
CB 53+56.45	4,466.32	4,465.70	4,470.46	4.14
CB 54+38.15	4,464.86	4,463.89	4,467.65	2.79
CO 35+74.23	4,534.02	4,533.37	4,545.08	11.06
CO 37+62.25	4,531.89	4,531.27	4,538.35	6.46
CO 38+15.53	4,531.24	4,530.57	4,537.47	6.23
CO 44+64.45	4,506.37	4,505.65	4,510.09	3.72
CO 45+57.11	4,504.01	4,503.30	4,507.56	3.55

Manholes

	Hydraulic Grade In (ft)	Hydraulic Grade Out (ft)	Elevation (Ground) (ft)	
CO 17+68.05	4,601.42	4,600.24	4,605.94	4.52
CO 26+17.17	4,571.17	4,569.99	4,582.15	10.98
CO 28+20.55	4,559.89	4,558.71	4,569.16	9.27
CO 30+48.12	4,544.33	4,543.56	4,548.49	4.16
CO 44+09.18	4,507.44	4,506.83	4,510.69	3.25
CO 46+48.91	4,498.87	4,498.23	4,502.52	3.65
CO 47+16.67	4,494.25	4,493.60	4,498.86	4.61
CO 48+27.15	4,485.98	4,485.35	4,495.08	9.10

- Governing Element

System Flow = **82** **cfs**

Downstream Half Analysis

Inlets

Label	Hydraulic Grade In (ft)	Hydraulic Grade Out (ft)	Elevation (Ground) (ft)	Distance from Ground to HGL
CB 9+53.60	4,637.29	4,633.60	4,633.60	-3.69
CB 10+10.00	4,639.87	4,632.22	4,632.22	-7.65
CB 13+59.72	4,626.55	4,618.90	4,618.90	-7.65
CB 17+01.49	4,611.73	4,608.04	4,608.04	-3.69
CB 18+53.98	4,606.53	4,602.47	4,602.47	-4.06
CB 21+30.28	4,598.42	4,594.73	4,594.73	-3.69
CB 24+62.71	4,588.74	4,584.90	4,584.90	-3.84
CB 25+24.14	4,586.18	4,581.82	4,584.52	-1.66
CB 32+45.62	4,542.39	4,541.11	4,541.11	-1.28
CB 33+92.85	4,542.83	4,541.08	4,545.00	2.17
CB 35+21.82	4,540.39	4,538.81	4,546.02	5.63
CB 36+82.48	4,536.46	4,535.06	4,541.21	4.75
CB 39+62.84	4,529.29	4,527.93	4,530.83	1.54
CB 41+22.78	4,515.93	4,514.59	4,517.49	1.56
CB 42+58.82	4,512.28	4,510.86	4,512.30	**0.02**
CB 48+71.21	4,482.34	4,480.65	4,493.76	11.42
CB 50+89.59	4,478.79	4,477.46	4,482.47	3.68
CB 51+62.84	4,476.96	4,475.60	4,479.83	2.87
CB 53+56.45	4,468.72	4,467.41	4,470.46	1.74
CB 54+38.15	4,466.78	4,464.75	4,467.65	0.87
CO 35+74.23	4,538.71	4,537.18	4,545.08	6.37
CO 37+62.25	4,534.53	4,533.25	4,538.35	3.82
CO 38+15.53	4,532.84	4,531.43	4,537.47	4.63
CO 44+64.45	4,508.03	4,506.51	4,510.09	2.06
CO 45+57.11	4,505.65	4,504.16	4,507.56	1.91

Manholes

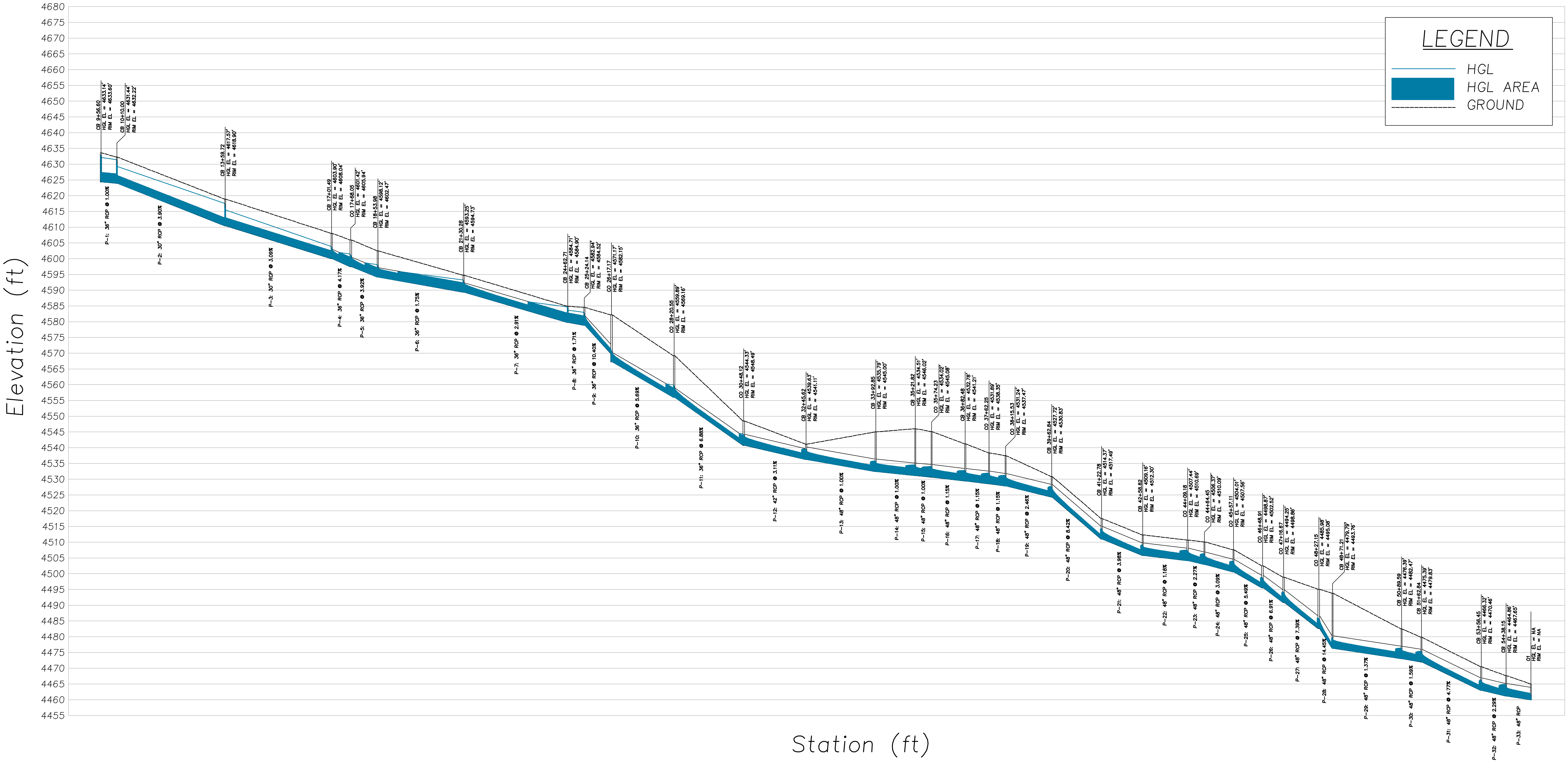
	Hydraulic Grade In (ft)	Hydraulic Grade Out (ft)	Elevation (Ground) (ft)	
CO 17+68.05	4,609.64	4,605.94	4,605.94	-3.70
CO 26+17.17	4,574.53	4,570.83	4,582.15	7.62
CO 28+20.55	4,562.62	4,558.92	4,569.16	6.54
CO 30+48.12	4,546.60	4,544.72	4,548.49	1.89
CO 44+09.18	4,509.41	4,508.35	4,510.69	1.28
CO 46+48.91	4,500.36	4,499.09	4,502.52	2.16
CO 47+16.67	4,495.75	4,494.46	4,498.86	3.11
CO 48+27.15	4,487.46	4,486.21	4,495.08	7.62

- Elements of the System that are not part of the lower analysis

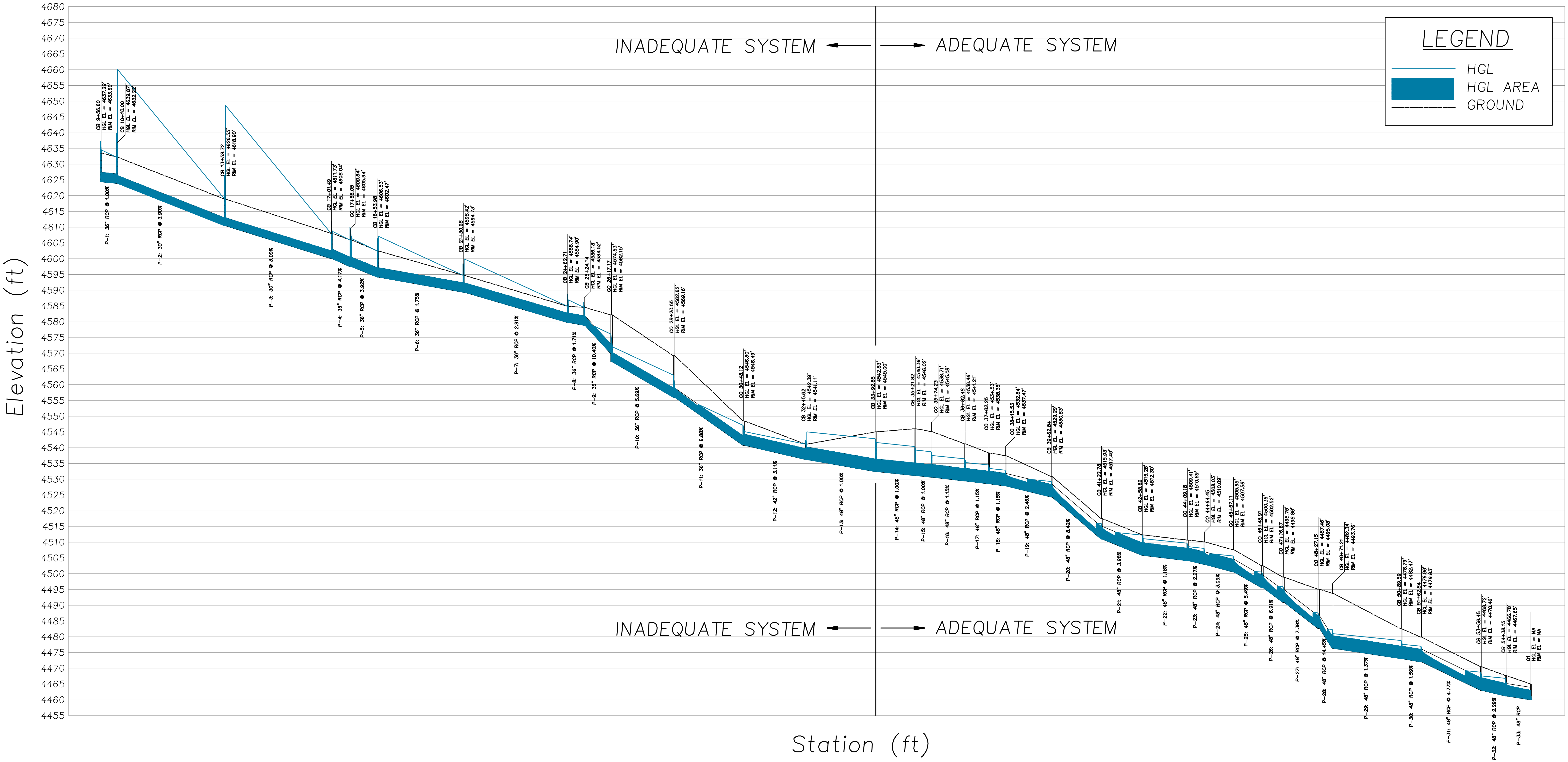
- Governing Element

System Flow = 154 cfs

Iron Horse Boulevard Storm Drain System – 82 cfs



Iron Horse Boulevard Storm Drain System — 154 cfs



Appendix G
Alternative Cost Estimates

OPINION OF PROBABLE PROJECT COSTS

for

Salt Lake County Wood Hollow Drainage

Alternative 1 - Large Regional Detention

Task Number	Item	Quantity	Unit	Unit Cost	Item Cost
1	**Remove Existing Service Road #1**				
	a. Land Acquisition	0.50	AC	$35,000	$17,500
	b. Cut/Haul/Finish	300	CY	$10	$3,000
					$20,500
2	**Remove Existing Service Road #2**				
	a. Land Acquisition	0.50	AC	$35,000	$17,500
	b. Cut/Haul/Finish	873	CY	$10	$8,730
					$26,230
3	***Regional Detention Pond (38.6 ac-ft)**				
	a. Land Acquisition Cost	11	AC	$140,000	$1,540,000
	b. Cut/Haul/Finish	75,800	CY	$10	$758,000
	c. UDOT cost participation for effects of MVC (assumed to contribute 23.7% of tasks 3a and 3b)	1	LS	-$544,626	($544,626)
					$1,753,374
4	**Provo - Reservoir Canal Crossing**				
	a. Land Acquisition Cost (This will be done by permit rather than acquisition)	0.25	AC	$0	$0
	b. Outlet from Regional Pond	1	EA	$3,000	$3,000
	c. SD pipe from pond outlet to outfall (Excludes saw-cut/hauling, and asphalt finishing cost)	280	LF	$185	$51,800
	d. Outfall structure and protection of channel	1	EA	$1,000	$1,000
	e. Concrete Flume	60	LF	$500	$30,000
					$85,800
5	**Open Channel Improvements** (Between Provo-Reservoir Canal and Camp Williams Road)				
	a. Land Acquisition Cost (40' wide by 1780' long)	1.63	AC	$84,000	$136,920
	b. Channel geometry improvements and channel armoring	900	LF	$50	$45,000
					$181,920
6	**Camp Williams Crossing**				
	a. No activity, improvements, or cost are required for this alternative (currently in place)	NA	NA	NA	$0
					$0
7	**Install SD Pipe from Camp Willims Crossing to Iron Horse Boulevard System**				
	a. No activity, improvements, or cost are required for this alternative (currently in place)	NA	NA	NA	$0
					$0
8	**Parry Farms Detention Pond Improvements**				
	a. Survey of Detention Pond - Assume half day for one crew of two men	1	LS	$520	$520
	b. Evaluation and Design	1	LS	$4,000	$4,000
	c. Install Improvements	1	LS	$10,000	$10,000
					$14,520
9	**Improve Storm Drain Line Downstream of Parry Farms Detention**				
	a. Survey of Storm Drain Line - Assume half day for one crew of two men	1	LS	$520	$520
	b. Evaluation and Design	1	LS	$4,000	$4,000
	c. Install Improvements (if needed)	1	LS	$15,000	$15,000
					$19,520
10	**Mobilization**				
	a. Assume 10% of all tasks 1 through 9	1	LS	$210,186	**$210,186**
		Subtotal			*$2,312,050*
		Contingency	*30%*		*$693,615*
	****The GRAND TOTAL without UDOT participation would be $3.71 million dollars***	***GRAND TOTAL***			***$3,005,666***

This estimate is an opinion of probable costs and is provided as a service to our client for comparative purposes only. It is based on prices current at the time this estimate was prepared. Actual costs and quantities may vary due to a number of circumstances including but not limited to: changes in field conditions, availability and/or cost of materials, methods and/or timing of construction, and inflation. No cost guarantee is expressed or implied. Please also refer to any other assumptions and qualifications. Land acquisition costs are subject to change and subjectivity due to the nature of the current economy.

PSOMAS

OPINION OF PROBABLE PROJECT COSTS

for

Salt Lake County Wood Hollow Drainage

Alternative 2 - Small Regional Detention, Additional Storm Drain Line

Item Number	Item	Quantity	Unit	Unit Cost	Item Cost
1	**Remove Existing Service Road #1**				
	a. Land Acquisition	0.50	AC	$35,000	$17,500
	b. Cut/Haul/Finish	300	CY	$10	$3,000
					$20,500
2	**Remove Existing Service Road #2**				
	a. Land Acquisition	0.50	AC	$35,000	$17,500
	b. Cut/Haul/Finish	873	CY	$10	$8,730
					$26,230
3	***Regional Detention Pond (7.6 ac-ft)**				
	a. Land Acquisition Cost	2.50	AC	$140,000	$350,000
	b. Cut/Haul/Finish	12,907	CY	$10	$129,070
	c. UDOT cost participation for effects of MVC (assumed to contribute 16.9% of tasks 3a and 3b)	1	LS	-$80,963	($80,963)
					$398,107
4	**Provo - Reservoir Canal Crossing**				
	a. Land Acquisition Cost (This will be done by permit rather than acquisition)	0.25	AC	$0	$0
	b. Outlet from Regional Pond	1	EA	$3,000	$3,000
	c. SD pipe from pond outlet to outfall (Excludes saw-cut/hauling, and asphalt finishing cost)	280	LF	$185	$51,800
	d. Outfall structure and protection of channel	1	EA	$1,000	$1,000
	e. Concrete Flume	60	LF	$500	$30,000
					$85,800
5	**Open Channel Improvements** (Between Provo-Reservoir Canal and Camp Williams Road)				
	a. Land Acquisition Cost (40' wide by 1780' long)	1.63	AC	$84,000	$136,920
	b. Channel geometry improvements and channel armoring	1,780	LF	$50	$89,000
					$225,920
6	**Camp Williams Crossing**				
	a. Install additional culvert under road parallel to existing 42" culvert (Including boring cost)	100	LF	$115	$11,500
					$11,500
7	**Bubble-Up Box for Connection to Iron Horse Boulevard System**				
	a. Box will include two invert ins (from Redwood Culvert) and two invert outs (42" inv. North and 36" inv. East)	1	LS	$4,500	$4,500
					$4,500
8	**Storm Drain Pipe through Pacificorp Land**				
	a. 36" RCP in place - Doesn't include saw-cut/haul, or asphalt finishing cost	2,000	LF	$100	$200,000
	b. Clean Out (Excludes saw-cut/haul and asphalt finishing work)	5	EA	$3,500	$17,500
	c. Utah Lake Distributing Canal Protection (Concrete Flume)	50	LF	$500	$25,000
	d. Land Acquisition (assumed 40' wide for 2000' of SD pipe)	1.84	AC	$75,000	$138,000
					$380,500
9	**Tie to Existing SD pipe system at CB 33+92.85**				
	a. Bore and grout line to existing structure, excavation and resurface grade	1	LS	3,000	$3,000
					$3,000
10	**Parry Farms Detention Pond Improvements**				
	a. Survey of Detention Pond - Assume half day for one crew of two men	1	LS	$520	$520
	b. Evaluation and Design	1	LS	$4,000	$4,000
	c. Install Improvements	1	LS	$10,000	$10,000
					$14,520
11	**Improve Storm Drain Line Downstream of Parry Farms Detention**				
	a. Survey of Storm Drain Line - Assume half day for one crew of two men	1	LS	$520	$520
	b. Evaluation and Design	1	LS	$4,000	$4,000
	c. Install Improvements (if needed)	1	LS	$15,000	$15,000
					$19,520
12	**Mobilization**				
	a. Assume 10% of all tasks 1 through 11	1	LS	$119,010	**$119,010**
		Subtotal			*$1,309,107*
		Contingency	*30%*		*$392,732*
	***The GRAND TOTAL without UDOT participation would be $1.81 million dollars**	***GRAND TOTAL***			***$1,701,839***

This estimate is an opinion of probable costs and is provided as a service to our client for comparative purposes only. It is based on prices current at the time this estimate was prepared. Actual costs and quantities may vary due to a number of circumstances including but not limited to: changes in field conditions, availability and/or cost of materials, methods and/or timing of construction, and inflation. No cost guarantee is expressed or implied. Please also refer to any other assumptions and qualifications. Land acquisition costs are subject to change and subjectivity due to the nature of the current economy.

PSOMAS

OPINION OF PROBABLE PROJECT COSTS

for

Salt Lake County Wood Hollow Drainage

Alternative 3 - Small Regional Detention, Upsize Storm Drain Line

Item Number	Item	Quantity	Unit	Unit Cost	Item Cost
1	**Remove Existing Service Road #1**				
	a. Land Acquisition	0.50	AC	$35,000	$17,500
	b. Cut/Haul/Finish	300	CY	$10	$3,000
					$20,500
2	**Remove Existing Service Road #2**				
	a. Land Acquisition	0.50	AC	$35,000	$17,500
	b. Cut/Haul/Finish	873	CY	$10	$8,730
					$26,230
3	***Regional Detention Pond (7.6 ac-ft)**				
	a. Land Acquisition Cost	2.50	AC	$140,000	$350,000
	b. Cut/Haul/Finish	12,907	CY	$10	$129,070
	c. UDOT cost participation for effects of MVC (assumed to contribute 16.9% of tasks 3a and 3b)	1	LS	-$80,963	($80,963)
					$398,107
4	**Provo - Reservoir Canal Crossing**				
	a. Land Acquisition Cost (This will be done by permit rather than acquisition)	0.25	AC	$0	$0
	b. Outlet from Regional Pond	1	EA	$3,000	$3,000
	c. SD pipe from pond outlet to outfall (Excludes saw-cut/hauling, and asphalt finishing cost)	280	LF	$185.00	$51,800
	d. Outfall structure and protection of channel	1	EA	$1,000	$1,000
	e. Concrete Flume	60	LF	$500.00	$30,000
					$85,800
5	**Open Channel Improvements** (Between Provo-Reservoir Canal and Camp Williams Road)				
	a. Land Acquisition Cost (40' wide by 1780' long)	1.63	AC	$84,000	$136,920
	b. Channel geometry improvements and channel armoring	1,780	LF	$50	$89,000
					$225,920
6	**Camp Williams Crossing**				
	a. Install additional culvert under road parallel to existing culvert (Including boring cost)	100	LF	$115	$11,500
					$11,500
7	**Upsize SD Pipe from Camp Willims Crossing to Iron Horse Boulevard System**				
	a. Tear out cost of existing SD line (no saw-cut or asphalt removal, excavation included in item 7b)	300	LF	$30	$9,000
	b. Upsize existing storm drain line (assumed 48", no asphalt finishing)	300	LF	$185	$55,500
					$55,500
8	**Storm Drain Infrastructure Upsize through Upper Half Iron Horse Blvd.**				
	a. 48" (size is preliminary) RCP in place (includes asphalt finishing cost)	2,440	LF	$225	$549,000
	b. Tear-out cost of existing SD line (saw-cut/removal, excavation costs included on line item 8a)	2,440	LF	$40	$97,600
	c. Replacement of each Man Hole and Clean Out	14	EA	$4,500	$63,000
					$709,600
9	**Tie to Existing SD pipe system at CB 33+92.85**				
	a. Bore and grout line to existing structure, excavation and resurface grade	1	LS	3,000	$3,000
					$3,000
10	**Parry Farms Detention Pond Improvements**				
	a. Survey of Detention Pond - Assume half day for one crew of two men	1	LS	$520	$520
	b. Evaluation and Design	1	LS	$4,000	$4,000
	c. Install Improvements	1	LS	$10,000	$10,000
					$14,520
11	**Improve Storm Drain Line Downstream of Parry Farms Detention**				
	a. Survey of Storm Drain Line - Assume half day for one crew of two men	1	LS	$520	$520
	b. Evaluation and Design	1	LS	$4,000	$4,000
	c. Install Improvements (if needed)	1	LS	$15,000	$15,000
					$19,520
12	**Mobilization**				
	a. Assume 10% of all tasks 1 through 11	1	LS	$157,020	**$157,020**
		Subtotal			*$1,727,217*
		Contingency	*30%*		*$518,165*
	***The GRAND TOTAL without UDOT participation would be $2.35 million dollars**	***GRAND TOTAL***			***$2,245,382***

This estimate is an opinion of probable costs and is provided as a service to our client for comparative purposes only. It is based on prices current at the time this estimate was prepared. Actual costs and quantities may vary due to a number of circumstances including but not limited to: changes in field conditions, availability and/or cost of materials, methods and/or timing of construction, and inflation. No cost guarantee is expressed or implied. Please also refer to any other assumptions and qualifications. Land acquisition costs are subject to change and subjectivity due to the nature of the current economy.

PSOMAS

OPINION OF PROBABLE PROJECT COSTS

for

Salt Lake County Wood Hollow Drainage

Alternative 4 - Small Regional Detention, Parallel Storm Drain Line

Item Number	Item	Quantity	Unit	Unit Cost	Item Cost
1	**Remove Existing Service Road #1**				
	a. Land Acquisition	0.50	AC	$35,000	$17,500
	b. Cut/Haul/Finish	300	CY	$10.00	$3,000
					$20,500
2	**Remove Existing Service Road #2**				
	a. Land Acquisition	0.50	AC	$35,000	$17,500
	b. Cut/Haul/Finish	873	CY	$10.00	$8,730
					$26,230
3	**Regional Detention Pond (7.6 ac-ft)**				
	a. Land Acquisition Cost	2.50	AC	$140,000	$350,000
	b. Cut/Haul/Finish	12,907	CY	$10.00	$129,070
	c. UDOT cost participation for effects of MVC (assumed to contribute 16.9% of tasks 3a and 3b)	1	LS	-$80,963	($80,963)
					$398,107
4	**Provo - Reservoir Canal Crossing**				
	a. Land Acquisition Cost (This will be done by permit rather than acquisition)	0.25	AC	$0	$0
	b. Outlet from Regional Pond	1	EA	$3,000	$3,000
	c. SD pipe from pond outlet to outfall (Excludes saw-cut/hauling, and asphalt finishing cost)	280	LF	$185.00	$51,800
	d. Outfall structure and protection of channel	1	EA	$1,000	$1,000
	e. Concrete Flume	60	LF	$500.00	$30,000
					$85,800
5	**Open Channel Improvements** (Between Provo-Reservoir Canal and Camp Williams Road)				
	a. Land Acquisition Cost (40' wide by 1780' long)	1.63	AC	$84,000	$136,920
	b. Channel geometry improvements and channel armoring	1,780	LF	$50	$89,000
					$225,920
6	**Camp Williams Crossing**				
	a. Install additional culvert under road parallel to existing culvert (Including boring cost)	100	LF	$115	$11,500
					$11,500
7	**Install Additional SD Pipe from Camp Willims Crossing to Iron Horse Boulevard System**				
	a. Install SD line parallel to recently constructed SD Line (assumed 36", no asphalt finishing)	300	LF	$100	$30,000
					$30,000
8	**Parallel Storm Drain Infrastructure through Upper Half Iron Horse Blvd.**				
	a. Install additional SD line parallel to existing SD line (assume 42" RCP including asphalt replacement)	2,440	LF	$160	$390,400
	b. Manholes and clean outs	14	EA	$3,500	$49,000
	c. Additional fees for constructions admin. And design to mitigate conflicts (assumed 10% of 8a and 8b)	1	LS	43,940	$43,940
					$439,400
9	**Tie to Existing SD pipe system at CB 33+92.85**				
	a. Bore and grout line to existing structure, excavation and resurface grade	1	LS	3,000	$3,000
					$3,000
10	**Parry Farms Detention Pond Improvements**				
	a. Survey of Detention Pond - Assume half day for one crew of two men	1	LS	$520	$520
	b. Evaluation and Design	1	LS	$4,000	$4,000
	c. Install Improvements	1	LS	$10,000	$10,000
					$14,520
11	**Improve Storm Drain Line Downstream of Parry Farms Detention**				
	a. Survey of Storm Drain Line - Assume half day for one crew of two men	1	LS	$520	$520
	b. Evaluation and Design	1	LS	$4,000	$4,000
	c. Install Improvements (if needed)	1	LS	$15,000	$15,000
					$19,520
12	**Mobilization**				
	a. Assume 10% of all tasks 1 through 11	1	LS	$79,543	**$79,543**
		Subtotal			*$1,354,040*
		Contingency	*30%*		*$406,212*
	***The GRAND TOTAL without UDOT participation would be $1.87 million dollars**	***GRAND TOTAL***			***$1,760,252***

This estimate is an opinion of probable costs and is provided as a service to our client for comparative purposes only. It is based on prices current at the time this estimate was prepared. Actual costs and quantities may vary due to a number of circumstances including but not limited to: changes in field conditions, availability and/or cost of materials, methods and/or timing of construction, and inflation. No cost guarantee is expressed or implied. Please also refer to any other assumptions and qualifications. Land acquisition costs are subject to change and subjectivity due to the nature of the current economy.

PSOMAS

Appendix H
Report Exhibits

Exhibit 1-Existing Facilities Inventory
1
2
3
4
5
6
7
Camp Williams Road
0 150 300 900 1,200
Feet
Legend
Man-Made Triangular Channel
Natural Open Channel
Iron Horse Boulevard Storm Drain (Pipe System)

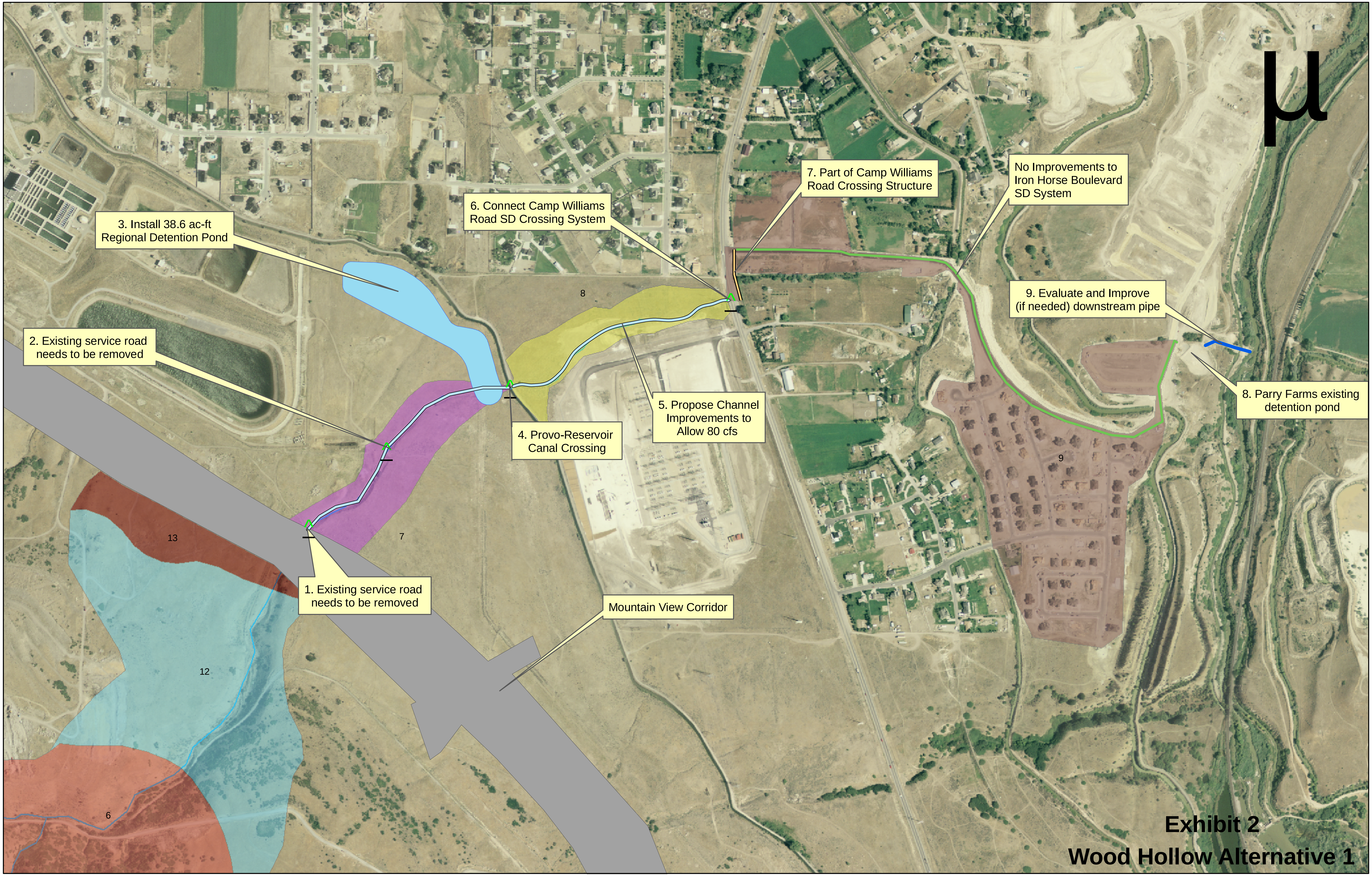
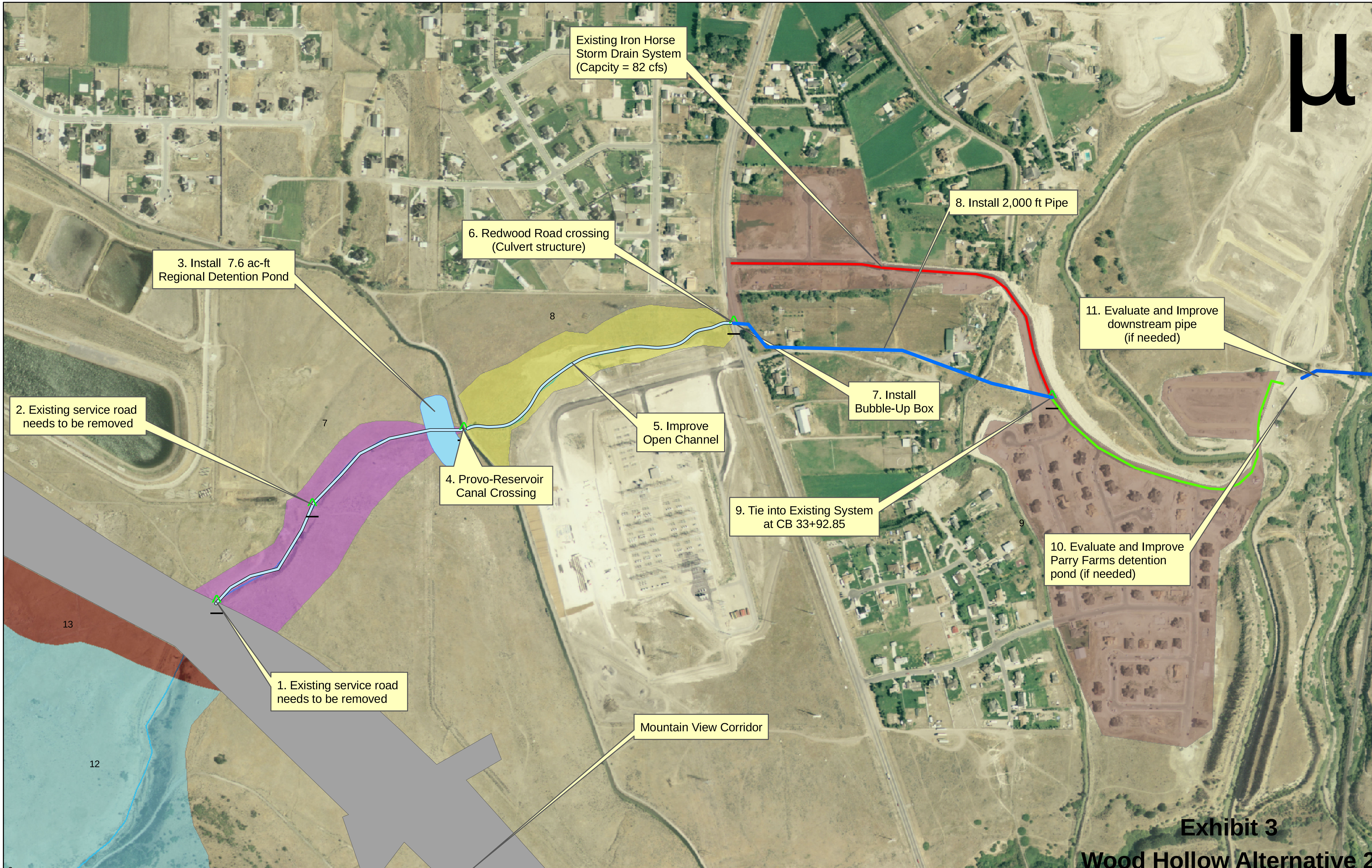


Exhibit 2

Wood Hollow Alternative 1


Existing Iron Horse Storm Drain System (Capcity = 82 cfs)
8. Install 2,000 ft Pipe
6. Redwood Road crossing (Culvert structure)
3. Install 7.6 ac-ft Regional Detention Pond
11. Evaluate and Improve downstream pipe (if needed)
8
7
2. Existing service road needs to be removed
5. Improve Open Channel
7. Install Bubble-Up Box
4. Provo-Reservoir Canal Crossing
9. Tie into Existing System at CB 33+92.85
9
10. Evaluate and Improve Parry Farms detention pond (if needed)
13
1. Existing service road needs to be removed
Mountain View Corridor
12
6
Exhibit 3
Wood Hollow Alternative 2

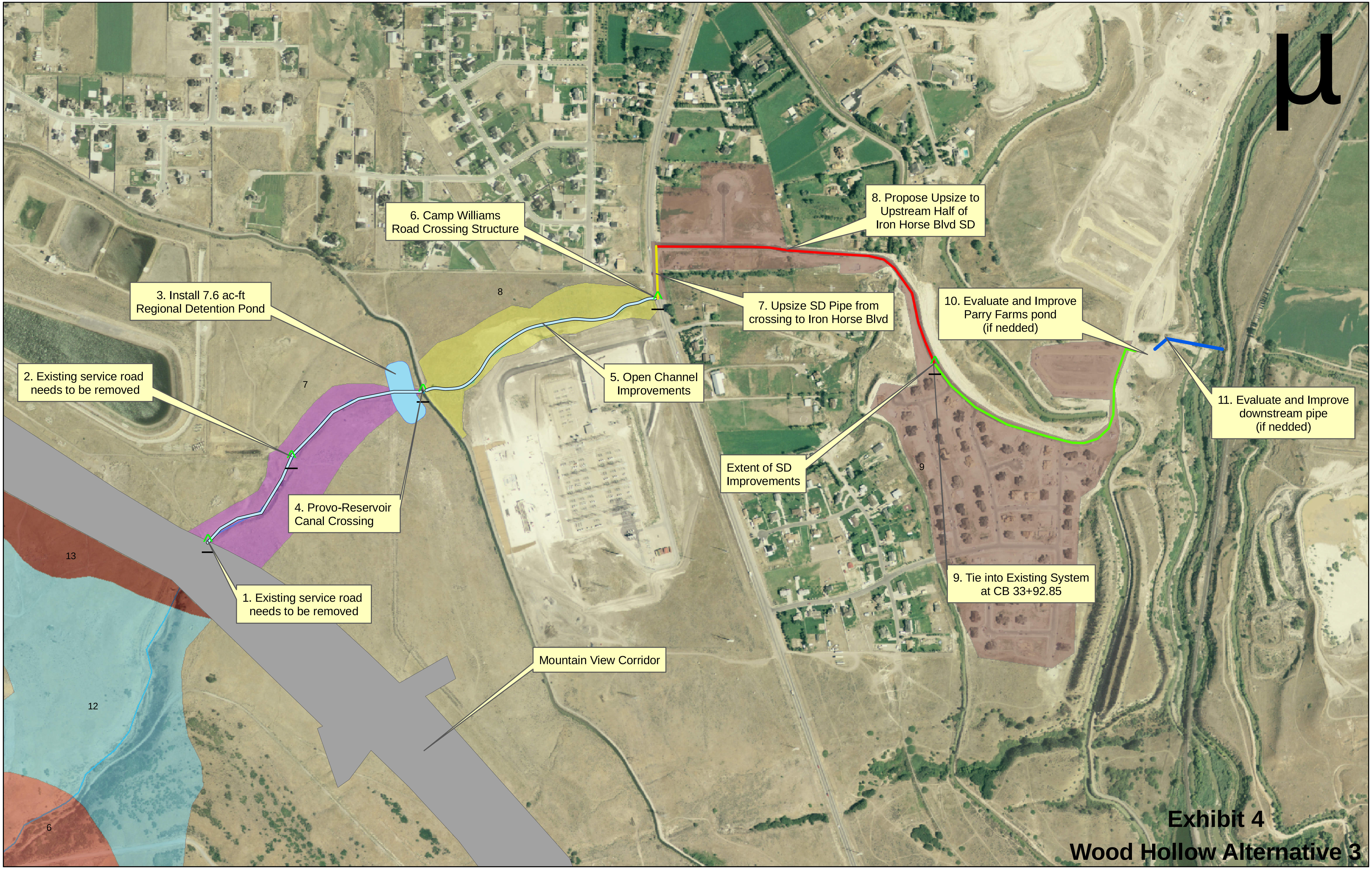


Exhibit 4

Wood Hollow Alternative 3

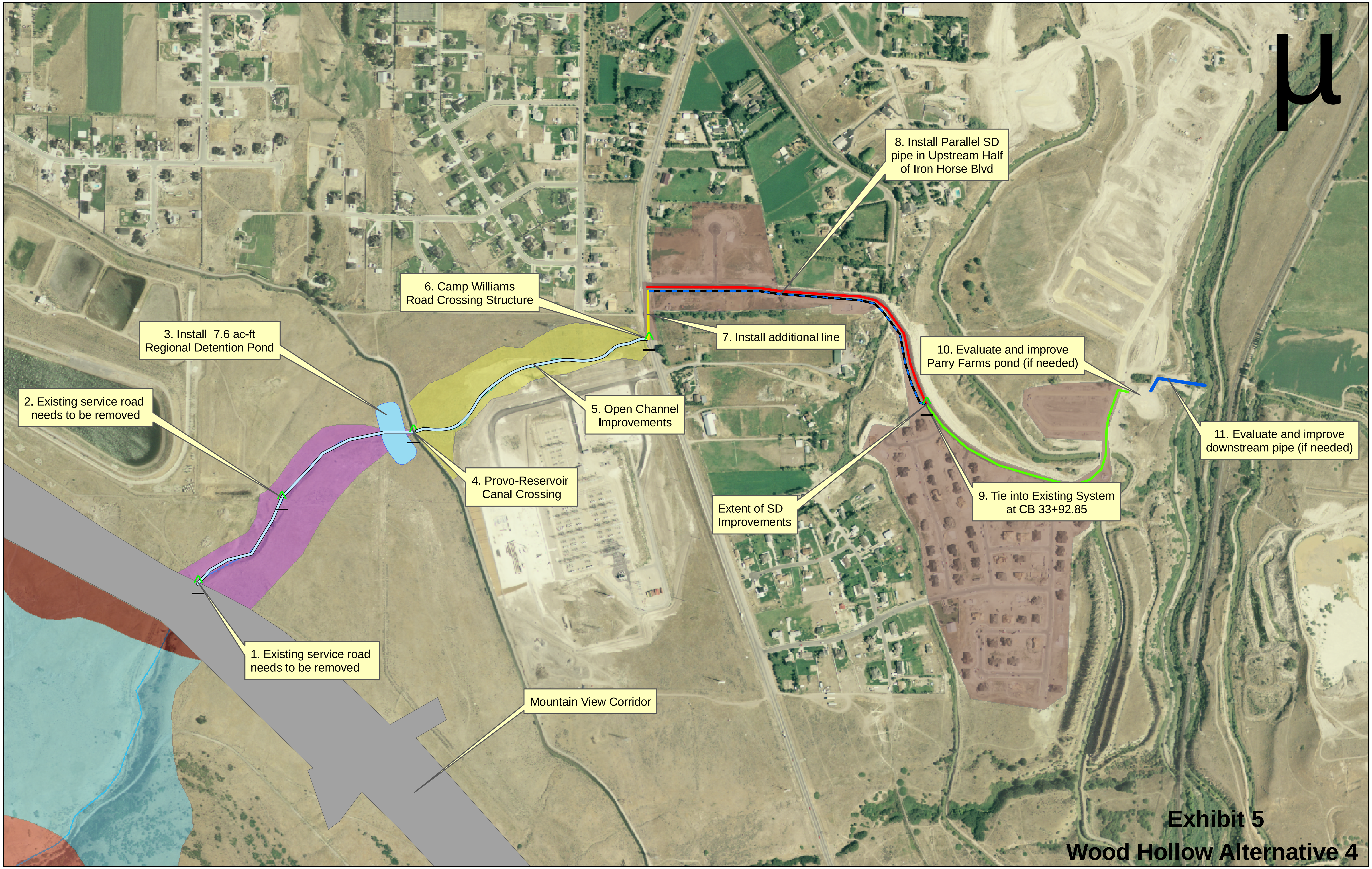


Exhibit 5
Wood Hollow Alternative 4

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