EXHIBIT A
ABREVIATED SUMMARY OF KETTLE CREEK BASIN DRAINAGE BASIN PLANNING STUDY

Drainage Basin Planning Study For Kettle Creek Basin

Prepared for:

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JR Project Number: 25100.00
May 5, 2015
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Drainage Basin Planning Study
For Kettle Creek

ENGINEER'S STATEMENT:

The attached Drainage Basin Planning Study was prepared under my direction and supervision and is correct to the best of my knowledge and belief. Said Drainage Basin Planning Study has been prepared according to the criteria established by the City for Drainage Basin Planning Studies and said report is in conformity with the master plan of the drainage basin area. I accept responsibility for any liability caused by any negligent acts, errors, or omissions on my part in preparing this report.

Steve Rossoll (signature) — COLORADO REGISTERED PROFESSIONAL ENGINEER STEVE ROSSOLL 34655 — 5/6/15

Steve Rossoll, Colorado P.E. # 34655 — Date

For and On Behalf of JR Engineering, LLC

DEVELOPER'S STATEMENT:

I, the developer, have read and will comply with all of the requirements specified in this Drainage Basin Planning Study.

Business Name: High Valley Land Company, Inc.

By: Thomas Taylor (signature)

Title: Vice President

Address: 1755 Telestar Drive, Suite 211
Colorado Springs, CO 80920

Phone Number: (719) 260-7477

CITY OF COLORADO SPRINGS ONLY:

Filed in accordance with Section 7.7.906 of the Code of the City of Colorado Springs, 2001, as amended.

(signature) — 5/13/15

For the City Engineer — Date

Conditions:

DISCLAIMER:

This report has been prepared based on certain key assumptions made by JR Engineering, which substantially affect the conclusions and recommendations of this report. These assumptions, although thought to be reasonable and appropriate, may not prove true in the future. The conclusions and recommendations made by JR Engineering are conditioned upon these assumptions.

Background information, design bases, and other data have been furnished to JR Engineering by third parties, which JR Engineering has used in preparing this report. JR Engineering has relied on this information as furnished, and is not responsible for and has not confirmed the accuracy of this information. Information that became available after data procurement was complete was not incorporated.

THIS REPORT IS A PLANNING DOCUMENT AND IS NOT TO BE USED AS THE BASIS FOR FINAL DESIGN, CONSTRUCTION OR REMEDIAL ACTION, NOR AS A BASIS FOR MAJOR CAPITAL DECISIONS.

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1 INTRODUCTION

1.1 Contract Authorization

This Drainage Basin Planning Study was authorized under the terms of an agreement between the City of Colorado Springs Engineering Development Review and Stormwater Departments and High Valley Land Company, Inc. and paid for with private funds. This study covers drainage development only within the Kettle Creek Drainage Basin.

1.2 Purpose and Scope

The purpose of the drainage basin planning study is to give an initial comprehensive study of the entire Kettle Creek Basin. This Study shall show the conduits, channels, natural drainage courses, detention reservoirs, easements, culverts and all other hydraulic facilities required to control surface water from the 100-year event within the Kettle Creek Basin and to carry such waters to points of insignificant impact and to develop a plan to address future stormwater and infrastructure needs within the Kettle Creek Watershed. The process used to develop a DBPS provides opportunity for interested parties to offer input on drainage issues, needs, and facilities within the watershed. The DBPS is intended to provide an inventory of required drainage facilities and determine a drainage fee per developed acre.

1.3 Past Studies

A complete Drainage Basin Planning Study (DBPS) has not been performed for the entire Kettle Creek Watershed. However, Master Development Drainage Plans (MDDP) and Final Drainage Reports (FDR) have been prepared for areas within the study area that have been developed in the last 13 years. A number of previous studies and reports were reviewed during the preparation of the current study. The most relevant studies are listed below along with a brief synopsis of the relevance of the current study. Additional reports that were reviewed are noted in the reference section of this study.

<u>Fountain Creek Watershed Study, January 2009</u>, U.S. Army Corps of Engineers.
The Fountain Creek Watershed Study ties together four separate studies, a hydrology report, a hydraulics report, and environmental conditions report, and a geomorphology report, into a watershed study establishing the objectives for reduced flood risk, erosion, and sedimentation in the Fountain Creek Basin. The Watershed Study presents percent change data for existing versus future peak discharges and volumes in Monument Creek and adjacent tributaries, although no Kettle Creek flow data is presented in the Watershed Study. The hydrologic study and hydraulic study were not available from the City of Colorado Springs or from the U.S. Army Corps of Engineers to compare hydrology for common basins at the time of the preparation of this DBPS.

<u>Master Development Drainage Plan For North Fork at Briargate</u>, May, 2014, by JR Engineering.
A proposed mixed use development comprised of a single family residential, multifamily, an elementary school, and park site. The Site covers 267 acres located north-east of Powers Boulevard and Old Ranch Road.

<u>Kettle Creek Drainage Basin Old Ranch Road Tributary Drainage Basin Planning Study and Master Development Drainage Plan</u>, April 2001, by JR Engineering. (Kettle Creek MDDP/DBPS)
This MDDP/DBPS covers the portion of the Kettle Creek Basin along old Ranch Road. This study provides hydrologic data for the existing and future development along Old Ranch Road, Creekside Estates, and drainage facilities at Pine Creek High School.

<u>U.S. Air Force Academy Kettle Creek Watershed Hydrology Study Findings and Recommendations Report</u>, March 2002, by URS Group, Inc. (AFA Study)
This report was prepared for the U.S. Air Force Academy to study the hydrologic, hydraulic, and sediment transport for the entire Kettle Creek basin. The report recommends alternatives to reduce sediment accumulation, evaluate Preble's meadow jumping mouse habitat, and enhance existing wetlands on Academy property.

<u>Flood Insurance Study for El Paso County and Incorporated Areas</u>
FEMA performed a Flood Insurance Study (FIS) in 1999 with detailed analysis and base flood elevations from State Highway 83 to Templeton Gap Road at the headwaters of Kettle Creek in the Black Forest. The FEMA FIRM maps and FIS data are included in **Appendix B**.

1.4 Stakeholder Process

Stakeholders who may be affected by this study results must be identified and included in numerous public meetings and presentations to committees, council and commissions. This DBPS is prepared for the High Valley Land Company, Inc. and is the only stakeholder that is affected in the Kettle Creek Basin study. Thus there are no stakeholder meetings and presentations required.

1.5 Agency Jurisdictions

Future development in the Kettle Creek basin will predominately be located within the City of Colorado Springs city limits. Improvements outside the city limits will be located and governed by El Paso County.

1.6 General Basin Description

The Kettle Creek watershed is located in the north central portion of El Paso County, Colorado. Kettle Creek and its tributaries originate on the southern slope of the Black Forest and flow in a southwesterly direction towards the City of Colorado Springs. The Kettle Creek watershed has a contributing area of approximately 16.41 square miles at its junction with Interstate Highway 25 (I-25).

The headwaters of Kettle Creek are located in the Black Forest, an area dominated by ponderosa pine forest and grassland on undeveloped large acreage tracts and 2- to 5-acre rural residential lots. In the vicinity of Powers Boulevard, the watershed changes to predominately undeveloped grassland. Downstream of Powers Boulevard, the watershed is dominated by residential development consisting of single-family homes, commercial centers, and vacant land. A vicinity map is provided in **Figure 1-1**.

1.7 Data Sources

Data used to complete the analysis for this DBPS, includes digital topography, aerial photography, soils classification, land use, existing stormwater infrastructure, rainfall data, U.S. Geological Survey (USGS) gage data, and pertinent information from previously completed studies. Topography covering the entire Kettle Creek watershed was obtained from USGS quadrangle maps (Black Forest, Falcon NW, Monument, Pikeview). Topographic data was imported using NAD83 (Colorado State Planes, Central Zone, US Foot) in accordance with the notes on the USGS quad maps. Aerial imagery was orthorectified using approximate methods of analysis. This USGS topographic data was only used for the hydrologic analysis. City of Colorado Springs FIMS topographic data was obtained for the reach of Kettle Creek studied in the hydraulic analysis.

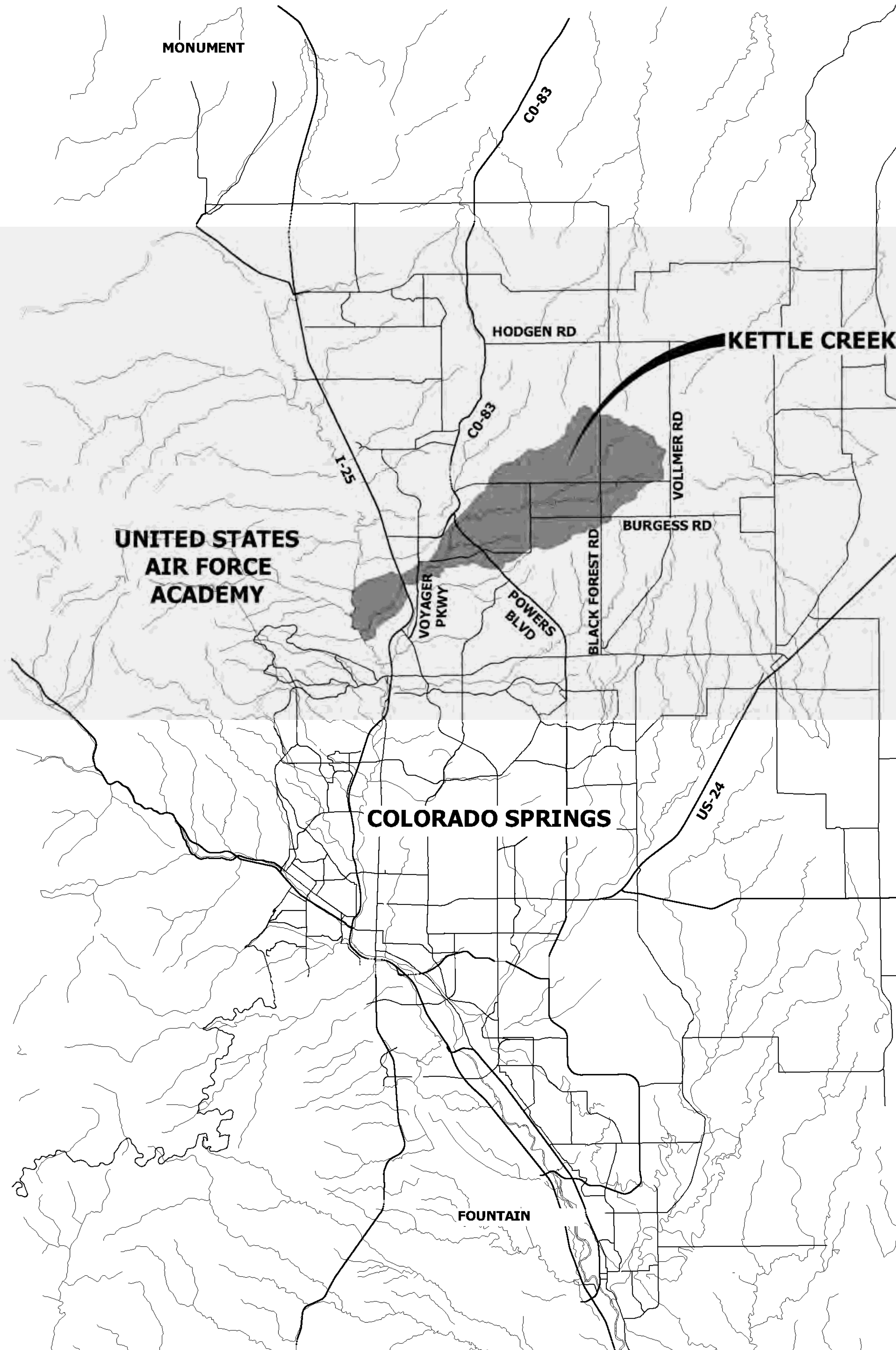
Rainfall data was obtained from the City of Colorado Springs Drainage Criteria Manual (DCM), Volume 1, dated May 2014. One-hour depths were obtained from the DCM and adjusted for elevation using the NOAA procedure. Soils data were obtained from the Natural Resources Conservation Service Web Soil Survey for El Paso County.

A hydrologic model for the Kettle Creek watershed was developed using the US Army Corps of Engineers (USACE) Hydrologic Engineering Center – Hydrologic Modeling System Version 4.0 (HEC-HMS) to simulate the rainfall-runoff process and generate flood hydrographs for select storm events.

A hydraulic model for the Kettle Creek channel was developed using the US Army Corps of Engineers (USACE) Hydrologic Engineering Center – River Analysis System Version 4.1.0 (HEC-RAS) to perform steady-state river hydraulics calculations with bridge analysis and stable channel analysis. City of Colorado Springs FIMS topographic data was used for the hydraulic analysis.

1.8 Applicable Criteria and Standards

The criteria and standards set forth in the City of Colorado Springs Drainage Criteria Manual (DCM), Volume 1 were applied to the entirety of the Kettle Creek DBPS for consistency, although much of the basin lies within unincorporated El Paso County. The Kettle Creek DBPS was prepared in accordance with the policies and procedures established in the DCM.



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2 1 0 2 4

ORIGINAL SCALE: 1" = 4 MILES

FIGURE 1–1 VICINITY MAP
KETTLE CREEK DBPS
JOB NO. 25100.00
MAY 2015

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2 BASIN CHARACTERISTICS

2.1 Location in Watershed, Offsite Flows, Size

The Kettle Creek watershed is located in the north central portion of El Paso County and flows southwesterly from the southern slope of the Black Forest towards the U.S. Air Force Academy. The Kettle Creek watershed contains perennial streams and has a contributing drainage area of approximately 16.41 square miles at its junction with Interstate Highway 25 (I-25). The entire Kettle Creek basin upstream of the U.S. Air Force Academy was studied for this DBPS, from the Kettle Creek headwaters in the Black Forest to I-25. Accordingly, no offsite flows are accounted for in this study.

The headwaters of Kettle Creek are located in the Black Forest, an area dominated by ponderosa pine forest and grassland on undeveloped large acreage tracts and 2- to 5-acre rural residential lots. In the vicinity of Powers Boulevard, the watershed changes to predominately undeveloped grassland. Downstream of Powers Boulevard, the watershed is dominated by residential development consisting of single-family homes, commercial centers, and vacant land.

2.2 Climate, Geology, and Environmental

2.2.1 Climate

The Kettle Creek watershed is located northeast of the City of Colorado Springs. The watershed ranges in elevation from approximately 6,410 feet at I-25 to approximately 7,600 feet at the north end of the basin in the Black Forest. Kettle Creek is tributary to Monument Creek and the confluence with Monument Creek is located near I-25 and Academy Boulevard. Kettle Creek is located at the north end of the Fountain Creek basin, which is tributary to the Arkansas River.

The climate of the region is classified as a mid-latitude steppe, with total annual precipitation averaging 16.2 inches annually. Eighty percent of the region’s precipitation comes in the growing season from March to October. Monsoon moisture in the form of thunderstorms in July and August contributes the most. Winter is the driest season of the year. The mean annual snowfall in the region is 84 inches with the peak amount in March.

2.2.2 Geology and Vegetation

The soils in the upper reaches of the Kettle Creek watershed, east of Power Boulevard, are predominately Kettle gravelly-loamy sand and Peyton-Pring complex. Smaller areas of Elbeth sandy loam and Tomah-Crowfoot sandy loam exist at higher elevations in the watershed. The dominant landform in this region is defined as hills, and the parent material is defined as arkosic alluvium derived from sedimentary rock and/or arkosic residuum weathered from sedimentary rock. The ecological site is specified as Sandy Divide. The soils in this region are all classified as Hydrologic Soils Group B. Group B soils are soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission. Surface runoff is slow, creating a low-to-moderate hazard of erosion. Native vegetation of the Kettle soil is predominately woodland ponderosa pine with a rooting depth of 60 inches.

West of Powers Boulevard, the soils composition changes. In the vicinity of Kettle Creek the soils composition remains similar with Kettle gravelly-loamy sand and Peyton-Pring complex, however away from the creek the dominant soils types are Blakeland loamy sand and Columbine gravelly sand, both of which belong to Hydrologic Soils Group A. Group A soils are soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well drained to excessively drained sands or gravelly sands. These soils have a high rate of water transmission. This region is located in a transition zone between forest, shrubland, and prairie. Much of the lower elevations are covered in Gambel oak and prairie grasses. The dominant landform in this region is defined as fans, fan terraces, floodplains, and swales, and the parent material is defined as alluvium derived from sedimentary rock and/or eolian deposits derived from sedimentary rock. The ecological site is specified as Gravelly Foothill.

2.2.3 Groundwater

Planning studies in adjacent basins (Falcon DBPS, prepared by Matrix Design Group, 2013) mapped the depth to groundwater in the Black Forest area and show that the water table is generally greater than 20 feet and more commonly greater than 100 feet below ground surface. It is assumed that these characteristics are typical throughout the upper reaches of the Black Forest area watersheds. The Falcon study speculated that the Black Forest is an infiltration area that recharges the Dawson aquifer because of the course-textured soils that dominate the forest. As groundwater from the Dawson aquifer flows south and southeasterly, it perches on the lower units of the formation (claystone and siltstone) and is 10 to 20 feet below the surface in some places. As elevation decreases in a southeasterly direction, the groundwater surfaces as low discharge springs or seeps. The hydraulic connection between the unconsolidated alluvial deposits in the unnamed tributaries and the Dawson aquifer is greatest where stream valleys have been eroded into the Dawson formation.

2.2.4 Development

Residential and commercial construction throughout the past 13 years has resulted in changes to the drainage pattern throughout the Kettle Creek watershed, particularly downstream of the Black Forest. These changes can either increase or decrease flows to various parts of the watershed. In multiple places, roadside ditches, culverts, and detention ponds have been constructed to manipulate historic flow patterns. These alterations can impact the drainage in two ways. First, the loss of hydrology from reducing flows to particular reaches will result in a change in vegetative structure. These areas have likely lost both wetland function and biodiversity. Second, diverted water may overload reaches that have not adapted to historic high flows. This condition usually results in bank erosion along the channel.

2.3 Major Drainageways and Structures

The major drainageway for the basin is Kettle Creek. Upstream of Powers Boulevard, storm runoff is captured in natural channels and conveyed to Kettle Creek predominately according to historic patterns. Kettle Creek has incised deep channels into the bedrock for much of its length.

Road crossings exist on Black Forest Road, Shoup Road, Milam Road, Powers Boulevard, Old Ranch Road, Voyager Parkway, and I-25. Many small culverts exist for Kettle Creek's smaller tributaries within the Black Forest, but were not considered in this analysis. These crossings were assumed to be adequate because minimal future development in the Black Forest area is expected to occur.

The existing bridges over Kettle Creek at Powers Boulevard, Old Ranch Road, and Voyager Parkway, as well as the regional detention facility at I-25, are assumed to be adequate for the current level of development and will remain for the future condition with no proposed modifications. Future development will be required to detain on-site to preserve the existing conditions discharges in Kettle Creek.

There are no known irrigation facilities in the Kettle Creek watershed.

2.3.1 Voyager Parkway/State Highway 83

It should be noted that later discussions refer to the Voyager Parkway crossing as "State Highway 83". Where the road is now owned by the City it is known as Voyager Parkway. Where the road remains CDOT controlled it is referred to as State Highway 83. Previous drainage studies use the old terminology and the designation State Highway 83 is kept herein to avoid confusion.

2.4 Existing and Proposed Land Uses

The Kettle Creek watershed reflects a variety of existing land uses including rural residential (5 acres, 2.5 acres, 0.5 acres), residential suburban (5000, 6000, 20000, some vacant), agricultural, planned unit development, commercial, and rights-of-way. Due to urban growth, land use is expected to change in the future condition with significant residential development planned in the lower-middle portion of the watershed. It is anticipated that the land uses in the Black Forest area will remain unchanged in the future condition.

3 HYDROLOGIC ANALYSIS

3.1 Major Basins and Sub-basins

3.1.1 Major Basin

The major basin was defined as the entire Kettle Creek watershed from its headwaters in the Black Forest to the I-25 crossing, approximately 16.41 square miles (10,506 acres). The I-25 crossing was determined to represent an adequate termination for the DBPS due to the proximity to the US Air Force Academy grounds (no basin development expected to occur) and the crossing is sufficiently downstream of future development within the Kettle Creek basin.

3.1.2 Sub-basins

The Kettle Creek watershed was divided into 32 sub-basins ranging from 0.12 square miles (79 acres) up to 1.33 square miles (853 acres). Slopes for areas of concentrated flow in the Kettle Creek watershed range from 0.69 percent to 9.64 percent, with shallower and steeper slopes located in the overland flow areas. Sub-basins were delineated at tributaries, major road crossings, changes in slope, changes in land use, and major drainage features. A routing schematic is provided in **Figure 3-1**. A drainage basin map is included as **Figure 3-2.**

3.1.2.1 Sub-basin Delineation

Topographic data for the hydrologic analysis of the entire watershed was obtained from USGS quadrangle maps (Black Forest, Falcon NW, Monument, Pikeview) and approximately traced into AutoCAD Civil 3D at 5-foot intervals.

The Kettle Creek watershed was divided into 3 major reaches: West Tributary, South Tributary, and East Tributary as shown on the basin map, **Figure 3-2**. The West Tributary consists of 19 sub-basins and 5 minor tributaries along the entire length of the watershed from the headwaters in the Black Forest to the crossing at I-25. These sub-basins primarily encompass rural land with pockets of residential development along the main stem of Kettle Creek. The East Tributary consists of 4 sub-basins and 1 minor tributary and encompasses rural residential land in the Black Forest. The Black Forest drains to The South Tributary. The South Tributary consists of 9 sub-basins and 2 minor tributaries. The area consists primarily of suburban residential located within the City of Colorado Springs city limits. This reach is where future development is expected to occur.

3.2 Methodology

3.2.1 Computer Models

A hydrology model for the Kettle Creek watershed was developed using the US Army Corps of Engineers (USACE) Hydrologic Engineering Center – Hydrologic Modeling System Version 4.0 (HEC-HMS) to simulate the rainfall-runoff process and generate flood hydrographs for select storm events. Each component of the model is described in detail following this section.

Sub-basin and stream reach physical characteristics including area, longest hydraulic flow path, reach length, slope, and topological connectivity were extracted for calculation of hydrologic parameters. Hydrologic parameters were calculated as outlined below and populated to the basin and meteorological components of the HEC-HMS model. A summary of selected methodologies for each HEC-HMS model component is provided in Table 3-1.

3.2.1.1 Rainfall Characteristics

The Specified Hyetograph method was chosen to model the hypothetical storm events as outlined in the City of Colorado Springs Drainage Criteria Manual (DCM), Volume 1, dated May 2014. Both the thunderstorm-type 2-Hour Design Storm Distribution (DCM Table 6-3) and the frontal-type NRCS 24-Hour Type II Design Storm Distribution (DCM Table 6-4) were applied to the point precipitation in order to generate the runoff hydrographs. Rainfall depths were obtained from Table 6-2 of the DCM and were verified for the higher elevations in the Kettle Creek watershed using the Urban Drainage and Flood Control District's UD-Rain Version 1.01 spreadsheet. At an average watershed elevation of 7120 feet, the 1-hour storm depth is 2.50 inches and the 24-hour storm depth is 4.60 inches. Point precipitation is shown in **Table 3-1**, below. Design storm input is included in **Appendix B**.

Table 3-1

Return	Rainfall Depth in Inches at Time Duration								
Period	*5-min*	*10-min*	*15-min*	*30-min*	*1-hr*	*2-hr*	*3-hr*	*6-hr*	*24-hr*
2-yr	0.34	0.54	0.68	0.78	1.19	1.37	1.50	1.70	2.10
5-yr	0.43	0.68	0.86	1.00	1.52	1.72	1.87	2.10	2.70
10-yr	0.49	0.78	0.98	1.14	1.73	1.96	2.13	2.40	3.20
25-yr	0.57	0.90	1.14	1.31	2.00	2.31	2.54	2.90	3.60
50-yr	0.64	1.02	1.28	1.48	2.26	2.58	2.82	3.20	4.20
100-yr	0.71	1.13	1.42	1.64	2.50	2.84	3.10	3.50	4.60

Depth Area Reduction Factors (DARFs) are used to adjust point rainfall depths to average depths as the size of drainage basins increase. The largest sub-basin analyzed was slightly larger than one square mile in area, therefore, all sub-basins received the same design storm distribution and no DARFs were applied. Although design storms for a 24-hour NRCS Type II distribution are integrated into the HEC-HMS software program and the program will create a DARF-adjusted design storm, the program's storm distribution was bypassed and the Specified Hyetograph method was selected. This results in a slightly conservative analysis for both storm distributions for the sub-basins above one square mile in area, which are all located in the upper segments of the Kettle Creek watershed.

The rainfall hyetographs were imported into the HEC-HMS precipitation gage manager and applied to each sub-basin within the Kettle Creek watershed. The Colorado Springs frontal-type NRCS 24-Hour Type II Design Storm Distribution yielded higher discharges and this storm was selected as the basis for analysis in the Kettle Creek DBPS.

3.2.1.2 Model Parameters

Infiltration and runoff volumes were modeled using the NRCS Runoff Curve Number (CN) Loss Method. The composite runoff CN was calculated for each sub-basin using the NRCS Curve Numbers for Frontal Storms & Thunderstorms for Developed Conditions (ARCII) (Table 6-10) from the DCM and the composite CNs were imported into HEC-HMS. For modeling purposes, initial infiltration loss rates were automatically calculated as functions of composite runoff CNs by HEC-HMS.

Peak flow rate and hydrographs for this study were computed using the SCS design storm method, which utilizes rainfall together with each sub-basin's physical characteristics to determine rainfall runoff for each sub-basin. Sub-basin lag times were calculated from the time of concentration as computed using the method outlined in the Colorado Springs Drainage Criteria Manual, Section 3. The process is described in more detail in the sections below.

a) Hydrologic Soil Groups

Soils are classified into hydrologic soil groups (HSG) by the NRCS for hydrologic modeling. The HSG is a parameter assigned to each soil series by the NRCS to reflect the relative rate of infiltration of water into the soil profile and is ranked according to infiltration potential from soils of high infiltration (HSG A) to soils of low infiltration (HSG D).

The HSG was determined for each of the soil mapping units from the NRCS Soil Survey data for the El Paso County. Of the four hydrologic soil groups, only A and B soils are found within the Kettle Creek watershed. Group B soils, with moderate infiltration rates, dominate the Kettle Creek watershed at 97.3% coverage. A hydrologic soil group map is provided in **Figure 3-3** that shows the distribution and coverage of each group within the Kettle Creek watershed.

Table 3-2
Soil Coverage by Hydrologic Soil Group

Land Use	Acreage	Coverage
HSG A	307	2.9%
HSG B	10,194	97.1%

b) Land Use

Historical land use conditions were assigned based on the land use categories defined in the DCM that are consistent with the native land uses within the watershed. Historical land use conditions represent an undeveloped watershed condition and were used as the underlying land use for runoff CN development as described below. Undeveloped land use conditions were classified under the appropriate category of "Other Agricultural Lands" in Table 6-9 of the DCM for NRCS Curve Numbers for Pre-Development Thunderstorms Conditions (ARC I). The land uses are classified as being in good, fair, or poor condition. Woods (Good Condition) is the dominant underlying land use in upper portion of the Kettle Creek watershed while Rangeland (Good Condition) is the dominant underlying land use throughout the remainder of the watershed. Each of these land uses categories were assigned a good condition based on field observation of ground cover.

Existing and future land use information for the Kettle Creek watershed was obtained from aerial imagery and El Paso County zoning information. Existing land uses were estimated form the aerial imagery (2011 and 2013). It was assumed that the land zoning can be used as a good indicator of fully developed conditions. The future land use data represents the current prediction of a full build-out scenario, sometime after 2030.

The Kettle Creek watershed reflects a variety of existing land uses including rural residential (5 acres, 2.5 acres, 0.5 acres), residential suburban (5000, 6000, 20000, some vacant), agricultural, planned unit development, commercial, and rights-of-way. Due to urban growth, land use is expected to change in the future condition with significant residential development planned in the lower middle portion of the watershed. It is anticipated that the land uses in the Black Forest area will remain unchanged in the future condition. Land use maps are shown in **Figure 3-4**, **Figure 3-5**, and **Figure 3-6** for historic, existing, and future conditions respectively. Summaries of land uses are shown in **Table 3-3**, **Table 3-4**, and **Table 3-5**, below.

Table 3-3
Historic Land Use Classes

Land Use	Coverage
Meadows, Good Condition, HSG A	2.3%
Herbaceous, Good Condition, HSG B	32.1%
Woods, Good Condition, HSG B	65.6%

Table 3-4
Existing Land Use Classes

Land Use	Coverage
Asphalt, HSG A	0.1%
Asphalt, HSG B	2.8%
Commercial Office, HSG A	0.3%
Commercial Retail, HSG B	0.4%
School, HSG B	0.6%
Meadows, Good Condition, HSG A	1.6%
Open Space Herbaceous, Good Condition, HSG B	14.3%
Residential (5 ac lots) and Herbaceous, HSG B	13.2%
Residential (5 ac lots) and Wooded, HSG B	55.7%
Residential (2.5 ac lots) and Wooded, HSG B	1.2%
Residential (2 lots per ac) and Wooded, HSG B	2.6%
Residential 1/4 ac lots, HSG A	0.8%
Residential 1/4 ac lots, HSG B	2.3%
Special Uses	4.2%

Table 3-5
Future Land Use Classes

Land Use	Coverage
Asphalt, HSG A	0.1%
Asphalt, HSG B	2.8%
Commercial Office, HSG A	1.0%
Commercial Retail, HSG B	0.6%
School, HSG B	0.7%
Meadows, Good Condition, HSG A	0.5%
Open Space Herbaceous, Good Condition, HSG B	4.3%
Residential (5 ac lots) and Herbaceous, HSG B	14.9%
Residential (5 ac lots) and Wooded, HSG B	55.6%
Residential (2.5 ac lots) and Wooded, HSG B	3.1%
Residential (2 lots per ac) and Wooded, HSG B	2.6%
Residential 1/4 ac lots, HSG A	0.8%
Residential 1/4 ac lots, HSG B	8.9%
Special Uses	4.2%

c) Runoff Curve Number Development

The Natural Resources Conservation Service (NRCS), U.S. Department of Agriculture, has instituted a soil classification system that relates the drainage characteristics of soil groups to a curve number, CN (SCS, 1972 and 1975). The NRCS provides information on relating soil group type to the curve number as a function of soil cover, antecedent moisture condition, and land use type. Curve number values were determined for each sub-basin. For the Kettle Creek basin, the predominant hydrologic soil group is B with an antecedent moisture condition of ARCII. The CN values differ between the existing and future conditions primarily to reflect the changes in the land use. Based on existing land use, zoning and known development plans, the basin is expected to generally change in places from an undeveloped pasture/woodland to low density residential. This is reflected by a 7% increase in the average basin CN from existing to future conditions. Tables illustrating the determination of the CN values are presented in **Appendix B**. Curve Number maps are shown in **Figure 3-7**, **Figure 3-8**, and **Figure 3-9** for historic, existing, and future conditions respectively. Curve number values for the respective land uses are shown in **Table 3-6**, below.

Table 3-6
Representative CN Values and Impervious Percentage by Land Use

Land Use	CN	Percent Impervious
Meadows, Good Condition, HSG A (Existing)	15	2
Herbaceous, Good Condition, HSG B (Existing)	41	2
Woods, Good Condition, HSG B (Existing)	34	2
Asphalt, HSG A	83	100
Asphalt, HSG B	89	100
Commercial Office, HSG A	89	95
Commercial Retail, HSG B	92	85
School, HSG B	72	40
Meadows, Good Condition, HSG A	39	2
Open Space Herbaceous, Good Condition, HSG B	62	2
Residential (5 ac lots) and Herbaceous, HSG B	65	15
Residential (5 ac lots) and Wooded, HSG B	65	15
Residential (2.5 ac lots) and Wooded, HSG B	65	20
Residential (2 lots per ac) and Wooded, HSG B	70	35
Residential 1/4 ac lots, HSG A	61	60
Residential 1/4 ac lots, HSG B	75	60
Special Uses	74	10

Average weighted curve numbers for the whole Kettle Creek basin are shown in Table 3-7, below.

Table 3-7
Average Weighted Runoff Curve Numbers

Condition	Curve Number
Historic [1]	36
Historic [2]	57
Existing	66
Future	69

[1] Uses Pre-Development curve numbers (ARC-I) for 2-Hour Storm
[2] Uses Post-Development curve numbers (ARC-II) for 24-Hour Storm

d) Initial Abstraction

The initial abstraction (I_a) represents a volume of rainfall that must fall to satisfy losses in a drainage basin before runoff begins. Per the DCM chapter 6, the default value for I_a is 0.10 times the potential maximum retention (S). To apply this adjustment when using HEC-HMS it is necessary to provide the initial abstraction as a depth in inches. The initial abstraction in inches is calculated according to the equation:

$I_a = 0.1\ [(1000/CN) - 10]$.

e) Time of Concentration

The times of concentration for the sub-basins were calculated according to the procedures outlined in the DCM, Chapter 6. The time of concentration is calculated following the guidance provided in TR-55 (NRCS 2005) by dividing the flow path into multiple segments. These segments can generally be categorized as overland flow, shallow concentrated flow and concentrated or channelized flow. For each of the flow segments, the estimated 2-year flow or the "low flow" should be used to calculate velocity. The time of concentration for the sub-basin is taken as the sum of the three flow regimes from the headwaters of the sub-basin to its discharge point.

f) Channel Routing

The Lag method was used for channel routing with lag times applied on an individual basis for each river reach. Lag times were calculated in accordance with Chapter 6 of the City DCM using Manning's equation to define average flow velocity. Approximate hydraulic characteristics for concentrated flow were used, taken from the UDFCD DCM Runoff chapter (Table RO-2). Reach delineations were performed for existing conditions and are unlikely to change significantly through later stages of development, as Kettle Creek and its tributaries are typically defined by deep earth channels with large areas of exposed bedrock.

3.2.1.3 Model Flow Diagram and Design Points

Design points were taken at every sub-basin junction where flow routing affected peak flows. In the model, reaches were used to connect junctions and provide routing of the concentrated flows at the specified length, slope, and roughness. A routing schematic is provided in **Figure 3-1**.

3.3 Basin Hydrology

The HEC-HMS model for the Kettle Creek watershed was run to simulate the rainfall-runoff process and generate flood hydrographs for historic, existing, and future land use conditions by applying a 2-hour and a 24- hour storm event with 2-, 5- 10-, 25- 50-, and 100-year recurrence intervals. As expected, future peak flows increased over existing conditions in conjunction with planned development. When compared to the 2-hour event, the 24-hour event has overall higher peak flows for the Kettle Creek basin and is therefore used for peak flow rates in the Kettle Creek DBPS hydraulic analysis and for floodplain delineation.

The results of the Kettle Creek Drainage Basin Old Ranch Road Tributary DBPS/MDDP by JR Engineering (2001) were used to represent the developed conditions discharge into Kettle Creek for existing and future development in the DBPS/MDDP study. The hydrographs for the detained releases into Kettle Creek replace the undetained sub-basin discharges in the HEC-HMS model.

The existing and future conditions hydrologic model results reported herein do not reflect any other existing, proposed, or conceptual future detention, channel improvements, or other alternatives described in later sections of this report. The intent of this DBPS is to provide a baseline for future development in the Kettle Creek Basin. Historic, existing, and future results are illustrated in **Figure 3-12**, **Figure 3-13**, and **Figure 3-14**, respectively.

3.3.1 Historic Flows

The Kettle Creek DBPS presented herein assumed an undeveloped condition throughout the entire basin for historic conditions. Historic land uses consisted of woods and semi-arid Herbaceous rangeland (See **Figure 3-4**). Using the aforementioned methods of analysis, the historic conditions analysis determined a peak historic flow of 705 cfs (5-year) and 2,381 cfs (100-year) at State Highway 83. Historic conditions flow data is presented in **Figure 3-10** and **Figure 3-11**.

3.3.2 Existing Flows

The existing conditions analysis used 2013 land uses as shown in **Figure 3-5** to determine curve numbers and percent impervious for the Kettle Creek Basin. The existing conditions analysis yielded flows of 1,766 cfs (5-year) and 4,114 cfs (100-year) at State Highway 83. To incorporate the existing regional detention ponds, Sub-basins 24 through 27 have been replaced by outflow hydrographs gathered from the Kettle Creek Drainage Basin Old Ranch Tributary MDDP/DBPS. Existing conditions flow data is presented in **Figure 3-10** and **Figure 3-11**.

3.3.3 Future Flows

The future conditions analysis made use of available City of Colorado Springs and El Paso County zoning information to determine the land uses at full basin build-out. Future land uses are shown in **Figure 3-6**. The future conditions analysis yielded flows of 1,796 cfs (5-year) and 4,152 cfs (100-year) at State Highway 83. To incorporate the existing regional detention ponds, Sub-basins 24 through 27 have been replaced by outflow hydrographs gathered from the Kettle Creek Drainage Basin Old Ranch Tributary MDDP/DBPS. Future conditions flow data is presented in **Figure 3-10** and **Figure 3-11**.

3.3.4 Flows Comparison

The results of this hydrologic analysis were compared with previous reports. In this DBPS, 5-year and 100-year peak inflows to the Kettle Creek detention facility at I-25 of 1,845 cfs and 4,250 cfs, respectively, were generated under existing watershed conditions. This study employed SCS methodologies along with NRCS-based soils and land use data specific to the Kettle Creek watershed. Composite CNs were calculated using NRCS attributes. The location of Kettle Creek at State Highway 83 (now Voyager Parkway) was used as a basis of comparison because it is presented in Volume I of the FIS. Detailed hydrologic results are presented in **Appendix B**. Flow results at State Highway 83 are shown in **Table 3-8** below:

Table 3-8
Flow Comparison at State Highway 83

Storm Recurrence Interval	Historic Flows (cfs)			Existing Flows (cfs)		Future Flows (cfs)	
24 Hr Duration	AFA Study	Kettle Creek DBPS	FIS Study	AFA Study	Kettle Creek DBPS	AFA Study	Kettle Creek DBPS
2	115	354	---	271	1,174	285	1,199
5	334	705	---	743	1,766	783	1,796
10	686	1,073	2,600	1,308	2,332	1,372	2,364
25	1,328	1,410	---	2,246	2,814	2,355	2,849
50	2,142	1,972	---	3,327	3,580	3,486	3,617
100	2,912	2,381	9,300	4,287	4,114	4,475	4,152

There are no previous DBPS studies for the entire Kettle Creek basin. An existing study available for flows comparison is the FEMA FIS for El Paso County and Incorporated Areas, dated August 23, 1999. The FIS used a joint Colorado Water Conservation Board (CWCB), a USACE study conducted on Monument and Fountain creeks with the USGS hydrologic report, Manual for Estimating Flood Characteristics of Natural-Flow Streams in Colorado (1976), and rainfall data from the Flood Hazard Analyses, Portions of Jimmy Camp Creek and Tributaries (October 1975) report, combined with the SCS Soil Survey for El Paso County (July 1981) to determine peak flow rates, using the empirical USGS regression equations for the southwestern United States. The FIS presents Kettle Creek as having a drainage area of 16.3 square miles, with peak discharges of 2,600 cfs (10-year) and 9,300 cfs (100-year) at State Highway 83 (now known as Voyager Parkway). No other hydrologic data is presented in the FIS. The discrepancies between the FIS, the AFA Study, and this DBPS are potentially due to the differing USGS and SCS methodologies.

The AFA Study reported 2-, 5-, 10-, 25-, 50-, and 100-year peak inflows as shown in **Table 3-8**. The study also employed SCS methodologies along with GIS-based soils and land use data specific to the Kettle Creek watershed. The discrepancies in peak flows between the Air Force Academy (AFA) and this study were due to minor differences in composite CNs, sub basin delineation and lag time calculations. The AFA also used a Kinematic Wave method for Channel Routing instead of the Lag Method used herein. Two sub-regional ponds in Sub-basins 24-27 were also modeled herein, whereas the ponds did not exist during the time of the AFA Study. The absence of these ponds would result in higher peak flows. The greater discrepancies in discharges with the smaller storm recurrence intervals are due to the Initial Abstraction values determined from the CNs. This DBPS uses an Initial Abstraction value of 0.1 times the potential maximum retention (S) in accordance with current City criteria, while the AFA study uses an Initial Abstraction value of 0.2 times S. Thus, the amount of water lost to infiltration during minor storm events is much greater in the AFA study.

Topography covering the entire Kettle Creek watershed was obtained from USGS quadrangle maps (Black Forest, Falcon NW, Monument, Pikeview) and was used for the hydrologic analysis of the basin only, and current electronic contours were obtained from the City for the hydraulic analysis. Hydrologic modeling inputs were obtained from this topographic data as well as following the SCS methodologies stated in the City of Colorado Springs Drainage Criteria Manual (May 2014). Version 4.0 of the HEC-HMS modeling software was employed. With a percent error of only five percent, the resulting 100-year peak flows form this model was comparable with results found from the AFA Study.

4 HYDRAULIC ANALYSIS

4.1 Major Drainageways

A hydraulic analysis was undertaken to evaluate the distribution of flow, determine areas covered by water during flooding events, and related characteristics of the water flow in the channel and overbank areas along Kettle Creek. While the hydrologic computations define the rate of flow for floods of selected frequencies at various points within the drainage basin, the hydraulic computations reflect dynamic conditions of the water flowing downstream as affected by the channel size, subsurface roughness, structures along the channel, channel vegetation, and similar physical characteristics. The physical characteristics of Kettle Creek and its tributaries in combination with the peak flood discharge rates described in Section 3 of this report provide the primary input characteristics to the hydraulic analysis, and the basis for evaluating the hydraulic adequacy of the outfall system.

Kettle Creek and its tributaries in the Black Forest area are defined in many places by deep channels with steep side slopes. A field investigation was conducted throughout the lower portion of the drainage basin, which will be the segment primarily affected by future development. It is understood that little future development is expected to occur in the Black Forest.

A field investigation was conducted from Powers Boulevard to I-25 in August 2014. The site investigation established a basis to define any areas in need of improvements, and determine the adequacy of the assumed channel characteristics and existing structures in this area. The visit also identified some areas where stream bank and bed erosion exists in the lower portion of the basin, and where other physical problems have resulted due to the stream hydraulics. Some of these areas are presented in **Appendix D** with photos taken in August 2014.

4.2 Methodology

Hydraulic calculations were performed on Kettle Creek to determine the existing and future floodplain limits. This was accomplished by utilizing the U.S. Army Corps of Engineer's HEC-RAS River Analysis System program (version 4.1.0, January 2010). For this study, Kettle Creek was divided into separate reaches corresponding to the designations as shown on **Figure 3-2**, and described in Section 3 of this report. The delineated historic, existing and future floodplain boundaries can be seen on the work maps, **Figures 4-1** and **4-2**, and the depths are depicted on the profile sheets included as **Figure 4-3** through **Figure 4-7**.

4.2.1 Parameters

Hydraulic analyses for existing and future hydrologic conditions were completed for the main stem of Kettle Creek from Howells Road to I-25. These analyses were completed to represent peak flows for the flood events with 2-, 5-, 10-, 25-, 50- and 100-year recurrence intervals. Cross-section topography data was obtained from a triangulated irregular network (TIN) in AutoCAD that was created from the contour information obtained from City of Colorado Springs FIMS topographic data.

4.2.2 Structures

Bridges and ineffective flow areas were added to the HEC-RAS model. Physical parameters for measured structures were incorporated into the hydraulic model using HEC-RAS bridge and cross-section data editors. All of the drainageway crossings from Powers Boulevard to I-25 were modeled to represent existing conditions which consist of bridges over Kettle Creek. These crossings are located at Powers Boulevard (bridge), Old Ranch Road (bridge), Otero Avenue (bridge), and Voyager Parkway (State Highway 83) (bridge).

4.2.3 Reaches

The reach analyzed consists of the Kettle Creek main stem from Howells Road (approximate, Howells Road does not cross Kettle Creek) to the Kettle Creek Detention Facility just east of I-25, approximately 24,850 linear feet or 4.7 miles of channel. This downstream limit extends 3,000 feet past the FIS and FEMA FIRM maps. The upstream limit of model was taken to be the approximate limit of significant planned future development at the east city limits. Upstream of Howells Road is the Black Forest (El Paso County jurisdiction), where land use is expected to remain unchanged in the future. The downstream limit was taken to be the embankment of the regional detention pond at I-25. Information from the U.S. Air Force Academy Kettle Creek Watershed Hydrology Study (April 2002) was used to determine the water surface elevations of the Kettle Creek detention facility for each respective storm recurrence interval.

The main stem of Kettle Creek in the subject reach is defined by a deeply incised main channel with heavy brush and wetland-type vegetation. Above the banks of the main channel, overbanks exist within the Kettle Creek drainageway with steep side slopes and natural grasses and sparse scrub vegetation.

4.2.4 Manning's *n* Values

The Manning's n values were applied across the channel cross-section to reflect changes in vegetative cover between the main channel and overbank areas. Manning's n values were obtained from the Major Drainage chapter of the UDFCD Drainage Criteria Manual. The Manning's *n* values for the channels and floodplains are summarized in Table 4-1.

Table 4-1

Manning's *n* Values

Parameter	Historic Conditions	Existing Conditions	Future Conditions
Main Channel *n*	0.100	0.100	0.100
Overbank *n*	0.030	0.030	0.030

The Manning's *n* for the main channel was selected for "very weedy reaches, deep pools, or floodways with heavy stand of timber and underbrush". Manning's *n* values for the overbank areas reflect conditions of "clean, straight, full stage, no rifts or deep pools". The channel characteristics are assumed to remain consistent through all stages of development.

4.2.5 Cross-Sections

A total of 44 cross-sections were modeled along the reach, with cross-sections located at geometry changes and downstream of all crossings. Channel cross-section locations were manually selected to represent confluences, changes in channel geometry and slope. Each cross-section was adjusted to extend across the estimated floodplain and was placed perpendicular to the anticipated direction of flow in both the main channel and left/right floodplains. The cross-sections were bent in some locations to accomplish the requirement to lie perpendicular to the flow path as described in Chapter 3 of HEC-RAS Hydraulic Reference Manual.

There are existing bridges over Kettle Creek located at Powers Boulevard, Old Ranch Road, Otero Avenue, and Voyager Parkway (State Highway 83). At each of these locations, four cross-sections were added to the HEC-RAS model that included an upstream cross-section prior to flow contraction, a cross-section at the upstream face of the structure, a cross-section at the downstream face of the structure, and a downstream cross-section where flow is fully expanded. Pier location and dimensions and deck elevations were roughly measured in the field. Photos are included in **Appendix D**.

The cross sections generated from the surface TIN in AutoCAD Civil 3D may potentially represent the top of the vegetated surface and not necessarily the true channel invert. In locations where vegetation is sparse, and not deep, the channel invert is assumed to be accurately represented. In locations of dense and deep vegetative cover, the channel invert may not be accurately represented and could be shallower that what actually exists. This condition may result in cross sections with less flood capacity than actually exists and leads to a conservative estimation of floodplain widths.

Several non-critical model warnings were generated during model runs. To address model warnings by either defining numerous additional cross sections or by interpolating cross sections between every defined cross section would be necessary. Neither of these solutions was determined to be necessary given the level of detail required for this study and as such were not completed.

Expansion and contraction coefficients in the cross-sections were estimated based on the ratio of expansion and contraction of the effective flow area in the floodplain occurring at cross-sections and at major drainageway crossings. For subcritical flow conditions where the change in the stream cross-section is gradual, a contraction coefficient of 0.1 and expansion coefficient of 0.3 are typically used for hydraulic modeling. The channel characteristics for the study reach justified the use of these typical values. An contraction coefficient of 0.3 and an expansion coefficient of 0.5 were used at the two upstream sections and immediate downstream section at each bridge crossing in accordance with standard practice, which reflects the energy loss resulting from increased flow contraction approaching the bridge, and increased flow expansion when leaving the bridge.

4.2.6 Ineffective Flow Areas

Ineffective flow areas are used to describe portions of a cross section in which water does not actively flow. Ineffective flow is typically used at the upstream and downstream bounding cross sections of a drainageway crossing and for a side channel with stagnant storage. All ineffective flow is considered permanent and will not become effective flow until the barrier is overtopped. Ineffective flow areas were used at major drainageway crossings only and it was assumed that channel invert irregularities are all contributing flow areas for the purposes of this study.

4.2.7 Bridges

The surface TIN was used to develop the bounding cross sections upstream and downstream of each major drainageway crossing, in addition to the approximate roadway characteristics at each crossing. The required inputs for bridge modeling include data for the deck/roadway, pier, and sloping abutments. This data was obtained from the surface topography and approximate measurements taken during the site inspection.

4.2.8 Detention Ponds

No existing detention ponds lie along the study reach except for the regional detention facility located on the upstream side of I-25. Information from the U.S. Air Force Academy Kettle Creek Watershed Hydrology Study (AFA Study) was used to determine the storage and water surface elevations of the Kettle Creek detention facility.

4.2.9 Steady Flow and Boundary Conditions

Steady flow data were entered for the study reach based on the results of the hydrologic modeling in Section 3. Steady flow data corresponding to the peak flow for flood events with recurrence intervals of 2-, 5-, 10-, 25-, 50- and 100-years for historic, existing, and future hydrologic conditions was entered for each reach at points of significant hydrologic change as determined in the hydrologic model. A summary of hydrologic flows for each tributary at different points is provided in tabular form in **Appendix B**.

The upstream boundary condition for the reach was based on the estimated normal depth of Kettle Creek based on invert slope. The downstream boundary conditions were based on water surface elevations in the I-25 regional detention pond obtained from the AFA Study. A mix of supercritical and subcritical flow conditions was evaluated. The mixed flow regime was selected to provide conservative water surface elevations while reflecting maximum velocities, in order to present the results most consistent with actual flood conditions in the channel.

4.3 Approximate Floodplains

After the HEC-RAS model analysis was complete, the 100-year water surface elevations were exported back to AutoCAD Civil 3D. Approximate floodplains for the existing and future 100-year floods were delineated for Kettle Creek and are shown in **Figures 4-1** and **4-2**. Due to negligible differences in the water surface profiles at the scale shown, the existing and future flow results are shown as one water surface profile. The FEMA floodplains for the Kettle Creek watershed are overlaid in the plan for comparison to the results of this analysis. Flood profiles for the existing and future 100-year floods are shown in **Figure 4-3** through **Figure**

4-7. The approximate floodplains and profiles were used to assess where potential drainageway crossing deficiencies exist along the major drainageways and identify areas of potential flooding.

The approximate floodplain information shown on the figures above is intended primarily for the identification of flood prone areas along the main stem of Kettle Creek and to aid in the evaluation of potential future alternatives. The approximate floodplain data contained herein is not intended to replace the information presented in the City of Colorado Springs and El Paso County Flood Insurance studies (FEMA 1999) but should be used as a planning tool for potential future drainageway development projects. The FEMA floodplain remains as the regulatory floodplain.

4.4 Drainageway Crossing Deficiencies

The four bridges over Kettle Creek in the hydraulic study area are sufficient based on approximate measurements of the structures during the site visit and estimates from aerial topography when compared to the calculated water surface elevation.

4.5 Areas of Geomorphic Instability

Several areas of erosion were located during the site visit and are noted in Appendix D. Due to the length of the reach and the heavy vegetation in the study reach, not all areas of instability may have been located.

The results of the hydraulic analysis show areas where flows approach or exceed critical depth, and the fluctuation of flows between subcritical and supercritical is a known cause of channel instability. Additionally, due to the Kettle gravelly loamy sand soil type, channel velocities in these areas that exceed five feet per second may be erosive. **Figures 4-8** to **4-12** shows areas that check structures could be implemented to accomplish a stabilized channel. These structures were placed in areas where the calculated cross section velocities of future flows were greater than five feet per second. Conceptual stable channel calculations are provided in **Figure 4-12**. Due to permitting requirements and the Preble's meadow jumping mouse critical habitat along Kettle Creek, the conceptual future improvements shown herein may not be feasible in some or all areas.

Future development in the lower Kettle Creek basin should address stabilization of the main channel in further detail. It will be the responsibility of each developer to perform a geotechnical analysis and detailed hydraulic study on the channel to determine the appropriate setbacks from the channel. Environmental considerations including Preble's meadow jumping mouse critical habitat will also dictate limits of development adjacent to Kettle Creek.

5 ENVIRONMENTAL EVALUATIONS

5.1 Significant Existing or Potential Wetland and Riparian Areas Impact

The EPA and US Army Corps of Engineers (Corps) defines wetlands as “those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas”. Wetlands are areas that are covered by water or have waterlogged soils for long periods during the growing season.

Per the Colorado Division of Wildlife Wetlands Mapping Inventory, Kettle Creek from just upstream of Old Ranch Road to its confluence with Monument Creek is located in a designated Colorado Natural Heritage Program Wetland Conservation Area.

At the time of development planning in the Kettle Creek basin, a Corps Jurisdictional Determination (JD) will need to be requested by the developer to determine if jurisdictional waters of the United States or navigable waters of the United States, or both, are either present or absent on a particular site.

5.1.1 Riparian Areas

Monument Creek and several tributaries, including Kettle Creek, are reported in the Survey of Critical Wetlands and Riparian Areas in El Paso and Pueblo Counties, Colorado, prepared by the Colorado Natural Heritage Program of Colorado State University for the Colorado Department of Natural Resources, dated June 27, 2001. Per the report, the Monument Creek systems has a biodiversity rank of B2 (very high biodiversity significance).

Downstream of the Black Forest, the riparian vegetation is dominated by coyote willow (*Salix exigua*), peachleaf willow (*Salix amygdaloides*), and crack willow (*Salix fragilis*) with scattered stands of narrowleaf cottonwood (*Populus angustifolia*). Also found in these mesic habitats are snowberry (*Symphoricarpos occidentalis*), wild plum (*Prunus americana*), and Russian olive (*Elaeagnus angustifolia*). Stream banks retain native graminoid vegetation in the form of sedges (*Carex* spp.) and rushes (*Juncus* spp.).

Surrounding uplands are generally midgrass prairie that is composed of smooth brome (*Bromopsis inermis*), cheatgrass (*Bromus tectorum*), big bluestem (*Andropogon gerardii*), needle-and-thread (*Stipa comata*), and little blue stem (*Schizachyrium scoparium*). Ponderosa pine (*Pinus ponderosa*) and Gambel's oak (*Quercus gambelii*) occur in patches on either side of Kettle Creek and its tributaries and increase in density at higher elevations in the watershed.

5.1.2 Wildlife

Several hundred birds, mammals, reptiles and amphibians inhabit the Kettle Creek watershed either as year-round residents or seasonally; all of which contribute to the functioning ecosystem as a whole. However, some species are of greater state and federal concern and are therefore either protected or managed for conservation and sustainability. For the purpose of the environmental evaluation, wildlife species described herein were selected based on regulatory priority.

5.1.2.1 Migratory Birds

The Migratory Bird Treaty Act (MBTA) of 1918, as amended protects the majority of birds in the United States with few exceptions (invasive birds). All active wild bird nests and bird eggs are federally protected under the MBTA. It is also illegal to wound or kill any bird protected by the MBTA except for those managed under regulated hunting seasons. Migratory birds within the Kettle Creek watershed can be found nesting in wetland and riparian areas, grassland/rangelands, forests, and within urban habitats. Migratory birds include perching birds (sparrows, warblers etc.), water fowl, game birds, and raptors (birds of prey).

5.1.2.2 State and Federal Threatened and Endangered Species

The U.S. Fish and Wildlife Service lists ten species as Threatened, Endangered, or Candidate under the Endangered Species Act in El Paso County. The State of Colorado also lists several dozen species as either State Endangered, State Threatened, or State Special Concern. While not federally protected, species of State Special Concern have a higher management priority by the Colorado Division of Wildlife.

The ten species listed under the Endangered Species Act in El Paso County include the Preble’s meadow jumping mouse, whooping crane, Mexican spotted owl, piping plover, least tern, greenback cutthroat trout, Pallid sturgeon, Arkansas darter, Western Prairie Fringed Orchid, and Ute-ladies’ tresses orchid. Of those species, the Preble’s meadow jumping mouse, Mexican spotted owl, and greenback cutthroat trout are the more likely to be encountered. The remaining species may either be found as occasional migrants or are listed for the County based on historical records.

5.1.2.3 Big Game

Big Game distribution within the Kettle Creek drainage basin includes the American black bear (*Ursus americanus*), pronghorn (*Antilocapra americana*), mule deer (*Odocoileus hemionus*), white-tailed deer (*Odocoileus virginianus*), and mountain lion (*puma concolor*). Both the mountain lion and black bear are known to occur in El Paso County and the ponderosa pine forest, riparian corridors, and forested wetlands within the Kettle Creek watershed provide suitable habitat. While it is possible for both species to follow drainages and forested areas from the mountains to the Kettle Creek watershed in search of food, their occurrence in the drainage area is likely uncommon. The drainage area has suitable habitat for elk, but their occurrence is also uncommon in the area. White-tailed deer, mule deer, and pronghorn are common both in El Paso County and within the Kettle Creek area. The construction of roads, water diversion structures, above-ground power lines, residential communities, and commercial sites impacts wildlife by fragmenting their habitat. Fragmentation can prevent animal movement or change movement patterns.

5.1.2.4 Other Significant Wildlife

The Bald and Golden Eagle Protection Act of 1940 provides further protections for eagles. While both Bald and Golden eagles are uncommon to rare in El Paso County, potentially suitable habitat does exist in the Kettle Creek watershed.

5.1.3 Preble's Meadow Jumping Mouse

The Monument Creek site supports an excellent (A-ranked) and a fair (C-ranked) occurrence of the globally and state imperiled Preble's meadow jumping mouse (*Zapus hudsonius preblei*), a species designated as sensitive, as federally threatened, and as a species of special concern. It is estimated that stresses may reduce the viability of the Preble's meadow jumping mice in the potential conservation area if protection action is not taken. Jumping mice have been documented in Kettle Creek outside of the U.S. Air Force Academy boundaries. This potential conservation area is of high significance because it is one of the best-known occurrences of Preble's meadow jumping mice in the Arkansas River drainage. The biggest threat to this conservation area is the encroachment of urban impacts.

The boundaries of the conservation area as presented in the Colorado Natural Heritage Program study were defined based on the presence of Preble's meadow jumping mice throughout the system. The boundary includes 300 meters on either side of the creek. This is designed to include the riparian vegetation and associated upland grass communities that have been documented as part of Preble's meadow jumping mouse habitat. The distance of 300 meters was intended to be conservative, likely including a greater amount of upland habitat than most mice will utilize, but sufficient to entirely cover the jumping mice habitat.

The City's Critical Habitat for the Preble's Meadow Jumping Mouse exhibit (see Appendix B) utilizes the stream width plus 120 meters (394 feet) on each side of the creek for the lower portion of Kettle Creek and tributaries, and the stream width plus 100 meters (361 feet) on each side of the creek for the middle portion of Kettle Creek (from approximately Old Ranch Road into unincorporated El Paso County). This Preble's meadow jumping mouse critical habitat width will dictate limits of development adjacent to Kettle Creek, in conjunction with the findings of geotechnical analyses and detailed hydraulic studies to be provided by each developer.

5.2 Stormwater Quality Considerations

The Colorado Department of Public Health and Environment (CDPHE) Water Quality Division has assembled a list of impaired waters in Colorado that have Total Maximum Daily Load (TMDL) restrictions for certain pollutants as required by Section 303d of the Clean Water Act. Kettle Creek is tributary to Monument Creek, which is tributary to Fountain Creek. Fountain Creek is tributary to the Arkansas River. The Arkansas River has 303d list TMDL restrictions to the state border, and Fountain Creek and Monument Creek are subject to E. coli monitoring and evaluation (CDPHE, 2012). The selenium water quality standard for Fountain Creek has a temporary modification for uncertainty. Kettle Creek and the unnamed tributaries in the Kettle Creek Watershed are not listed and, therefore, are not subject to Section 303d TMDL restrictions.

5.2.1 Hazardous Materials

A search of EPA Superfund sites and National Priorities List sites yielded no sites in the Kettle Creek watershed or in the vicinity of the watershed. Multiple facilities were listed on the EPA Facility Index System/Facility Registry System (FINDS) database in the Kettle Creek watershed, reflecting facilities which are regulated by the EPA but not necessarily in violation.

5.2.2 Water Quality

Water quality treatment shall be required for all stormwater detention basins within the City of Colorado Springs. The City will hold all development tributary to Kettle Creek to USAFA release standards.

5.3 Permitting Requirements

The portions of the Kettle Creek watershed to be developed must comply with all applicable El Paso County, and where applicable, City of Colorado Springs requirements for planning and zoning. A Permit from the Corps will be required to discharge fill or dredged material into jurisdictional waters. Additionally, due to the presence of the Preble's meadow jumping mouse, appropriate permits from the U.S. Fish and Wildlife Service may be required. Ongoing coordination with the U.S. Fish and Wildlife Service will be required to identify outfall points and limits of disturbance. Maintenance of the natural drainageways and features while providing stability for the Kettle Creek channel will be required. City and County review and approval will be necessary at all stages.

6 ALTERNATIVES EVALUATION

6.1 Evaluation Criteria

The purpose of an alternatives analysis for a DBPS is to synthesize the study results and to evaluate detention and reach improvement options. The outcome of detention alternatives and reach alternatives is typically presented at public meetings for shareholder and public discussion. The outcome of this section is a recommended detention alternative and prioritization to be carried forward to the plan development design phase for further analysis.

The full spectrum detention approach, as defined in Chapter 13 of the City Drainage Criteria Manual, shall be implemented as the standard detention approach. A result of full spectrum detention is that discharges from storms smaller than approximately the 2-year event will be reduced to very low flows near or below the sediment carrying threshold value for downstream drainageways. Full spectrum detention provides better control of the full range of runoff rates that pass through detention facilities than the conventional multi-stage concept. This concept also provides some mitigation of increased runoff volumes by releasing a portion of the increased runoff volume at a low rate over an extended period of time (up to 72 hours). The full spectrum detention approach is necessary for development in the Kettle Creek watershed because it reduces the flooding and stream degradation impacts associated with urban development by controlling peak flows in the stream for a wider range of events than traditional multi-stage detention outlet concepts.

6.2 Regional Detention Alternatives

The channel and structure capacities were determined to be sufficient for the historic, existing, and future conditions 100-year flood event, as presented in Section 4. However, it was determined that the existing and future levels of development in the Kettle Creek basin have an appreciable impact on the flow rates compared to historic rates, with potentially adverse impacts of erosion and deposition resulting from the higher flows.

As shown in the hydrologic results, the post-development hydrographs for Kettle Creek leaving the Black Forest reflect significant increases in flow rates. The objective of regional detention at this location is to mitigate impacts to the downstream channel caused by development in the Black Forest. To adjust the Kettle Creek flow rates to historic levels, two regional detention alternatives are viable along with a do-nothing alternative as it relates to regional detention:

- Regional detention upstream of Powers Boulevard within City open space,
- Regional detention upstream of Old Ranch Road within City open space, and
- No new regional detention facilities.

While it has been shown that multiple ponds placed in a parallel configuration (located on tributaries to major drainageways and serving relatively small drainage areas, as opposed to being placed on the major drainageways themselves) provide a better opportunity to accomplish stormwater management goals and results in lower overall system costs, development has taken place in the Black Forest over the last few decades without stormwater detention considerations and existing land use and ownership makes sub-regional detention in the Black Forest impractical. Therefore, the regional detention alternatives proposed herein are by necessity located downstream of the Black Forest.

Per the City DCM, a regional detention facility should not serve a contributing area larger than 640 acres (one square mile). The design assumptions used to size the facilities, including uniform rainfall and undeveloped allowable release rates become less reliable with larger basins. Larger basins are also increase long term sediment loads and maintenance requirements. Limiting the contributing area to 640 acres also reduces the likelihood of the structure being regulated by the State Engineer’s Office as a jurisdictional dam. The conceptual alternatives proposed herein would serve a contributing area larger than 640 acres, but the limitations in location for new regional detention facilities in the Black Forest preclude adherence to City and County criteria for the subject regional detention facility alternatives.

The regional detention option upstream of Powers Boulevard would be located within City open space (City of Colorado Springs 2020 Land Use map) and would detain flows from the Black Forest area just inside City limits. This would protect the Kettle Creek drainageway from Powers Boulevard to I-25 by discharging at historic rates.

Regional detention upstream of Old Ranch Road would accomplish the same objective but would make use of more available land (as determined from the City of Colorado Springs 2020 Land Use map). The larger tributary area would result in an overall increase in the storage requirements of the pond.

For both aforementioned regional detention options, off-line storage via a diversion of a portion of the Kettle Creek flows would allow for more usable open space with an attractive, multipurpose facility that is readily maintainable and safe for the public, under both dry and wet conditions. A facility that is located in-line with the drainageway and captures and routes the entire flood hydrograph is feasible, but is less advantageous because an in-line facility must be large enough to handle the total flood volume of the entire tributary catchment.

The do-nothing approach as it relates to regional detention would allow developed conditions discharges from the upper portion of the basin to continue to impact the stability of the channel in the lower reach of Kettle Creek. This alternative would make use of the existing regional detention at I-25 but would not provide any additional flood flow attenuation for managing channel-forming flows or flood flows higher in the watershed. This option may put Kettle Creek at risk for continued erosion, deposition, and flooding. However, the mandatory sub-regional detention approach as described in the following sections would limit discharges from new development to historic rates. Without regional detention higher in the reach, however, the Kettle Creek channel within City of Colorado Springs limits would still be subject to periodic flooding above historic rates caused by development higher in the basin.

The regional detention alternatives presented herein only are considered for the purposes of attenuating developed flow rates. Consideration of regional detention alternatives will have significant environmental impacts as discussed in Section 5. Sub-regional detention alone will not reduce flow rates in Kettle Creek to historic levels, as past development in the upper portion of the basin is a contributing factor to the increased flows under existing conditions. Regional detention must be owned and maintained by a public entity, with ownership and maintenance responsibilities clearly defined to ensure the proper function of the facility in perpetuity.

6.3 Sub-Regional Detention

The anticipated approach is sub-regional detention with full spectrum detention and water quality treatment. Any future development in the Kettle Creek basin within the City of Colorado Springs shall have sub-regional detention for each development/phase. Detention facilities serving drainage basins between 20 and 130 acres are considered "sub-regional detention". Sub-regional detention may be constructed by a public entity such as a municipality or special district to serve several landowners in the upstream watershed or by a single landowner. It may be possible for a single landowner to construct sub-regional detention if the upper part of the watershed is owned by others and if the necessary conditions are achieved. Sub-regional detention should be addressed in subsequent Master Development Drainage Plans (MDDP) for individual development projects. The ownership and maintenance of these ponds are anticipated to be public or quasi-public. In order to be considered for public maintenance the contributory area shall be in the range of 70-120 acres. A conceptual map illustrating the locations of required sub-regional detention facilities is shown in **Figure 6-1**.

6.3.1 Full Spectrum Detention

The full spectrum detention approach, as defined in Chapter 13 of the DCM, shall be implemented as the standard detention approach. Impervious surfaces associated with development increase peak flows, frequency of runoff and total volume of stormwater surface runoff when compared to pre-development conditions. This increase is most pronounced for the smaller, more frequent storms and can result in stream degradation and water quality impacts as well as flooding during large storm events.

In addition to detaining developed conditions stormwater discharge for flood control and for water quality considerations, it is also important to expand the focus to the range of flows responsible for transporting the most bedload in the receiving stream. This range depends on reach specific characteristics but is between the annual event and the 5-year event. Runoff events in this range can produce geomorphic changes in local receiving streams resulting in severe erosion, loss of riparian habitat, and water quality degradation.

Outflow hydrographs from traditional flood-control detention facilities tend to maintain flows near the maximum release rates for relatively long periods of time. This allows hydrographs released from multiple independent ponds to overlap and add to each other to generate flows exceeding pre-development conditions. Traditional flood-control detention concepts can result in an increase in total watershed discharges even if individual detention facilities each control peak discharges to pre-developed conditions. Full spectrum detention modeling reduces urban runoff peaks to levels similar to pre-development conditions for a wide range of storms over an entire watershed, even with multiple independent detention facilities. A result of full spectrum detention is that discharges from storms smaller than approximately the 2-year event will be reduced to very low flows near or below the sediment carrying threshold value for downstream drainageways.

6.3.2 Water Quality

Each sub-regional detention pond shall detain flows not only for flood control, but also for water quality. The Water Quality Capture Volume (WQCV) is intended to capture most runoff events and reduce their pollutant load prior to discharging into drainageways. The size of this storage element depends primarily on the amount of tributary impervious area and can be reduced by implementing development practices that reduce the effective imperviousness, discussed in more detail below.

Future development in the basin shall consider other land planning and engineering design approaches to manage stormwater runoff and water quality. Low Impact Development (LID) is a comprehensive approach with the goal of mimicking the pre-development hydrologic regime. LID emphasizes conservation of natural features and use of engineered, on-site, small-scale hydrologic controls that infiltrate, filter, store, evaporate, and detain runoff close to its source. Portions of the site that aid in reducing the developed conditions discharge should be preserved, which may include mature trees, stream corridors, wetlands, and NRCS Type A/B soils with higher infiltration rates.

Minimizing Directly Connected Impervious Area (MDCIA) includes a variety of runoff reduction strategies based on reducing impervious areas and routing runoff from impervious surfaces over grassy areas to slow runoff and promote infiltration. MDCIA is a technique for reducing runoff peaks and volumes following urbanization. Paved areas can be reduced in extent to the minimum amount practical, and implement methods to route runoff over grassed areas rather than directly into storm sewer. When soils vary over the site, concentrate new impervious areas over NRCS Type C and D soils, while preserving NRCS Type A and B soils for landscape areas and other permeable surfaces. Increasing the number and lengths of flow paths will all reduce the impact of the development.

Volume reduction is a key hydrologic objective, as opposed to peak flow reduction being the only objective. Volume reduction is emphasized not only to reduce pollutant loading and peak flows, but also to move toward hydrologic regimes with flow durations and frequencies closer to the natural hydrologic regime.

6.4 Limited Channel Stabilization Alternative

Channel improvements may be necessary in the main study reach of Kettle Creek to limit erosion and deposition resulting from high velocities as determined in Section 4. However, grading and grade control structures may not be feasible in Kettle Creek due to the disturbance they would cause with the presence of the Preble's meadow jumping mouse. Conceptual check structure placement is provided for reference, should grade control structures become an option in the future.

The locations of these conceptual check structures were determined by areas where mean channel velocities exceeded 5 feet per second for the 100-year event. Future grade between check structures was estimated to stabilize at approximately 0.20 percent. Check structure placement was shown to lower velocities above 5 feet per second and to stabilize the channel. Channel improvements may be determined to be necessary in locations where public or private facilities would be in danger if the creek migrates.

7 SELECTED PLAN

The anticipated approach is sub-regional detention with water quality treatment. Any future development in the Kettle Creek basin within the City of Colorado Springs shall have sub-regional detention for each development/phase. No regional detention is considered at this time.

Water quality treatment shall be required for all stormwater detention basins within the City of Colorado Springs. The City will hold all development tributary to Kettle Creek to USAFA release standards.

8 FEE DEVELOPMENT

8.1 General

The objective of the fee development exercise is to determine the equitable share of drainage improvement costs that a developer is responsible for paying to the City of Colorado Springs if they wish to plat a property. The end product of this section is typically a unit fee (cost/acre) that is a one-time charge to the developer for their portion of the reimbursable infrastructure. In the case of Kettle Creek it is expected that no drainage fees will be required and will be considered a closed basin

The City of Colorado Springs map "City of Colorado Springs Fee Basins" shows Kettle Creek as "misc. – unstudied". There has been a master development drainage report completed on a portion of Kettle Creek, which is currently a closed subbasin with no City drainage, bridge, or detention/land fees and no reimbursement for constructed improvements. El Paso County assesses an $8,100 drainage basin fee for development in the Kettle Creek basin.

8.2 Developable Land

The Kettle Creek watershed has a total area of 10,506 acres. The majority of the watershed is within El Paso County 8,500 acres, with only approximately 1,253 acres of City land unplatted, according to calculations taken from the County Assessor's site. This land calculation also includes unplatted areas that cannot be developed because of specific land use designations. A complete summary of unplatted area land use is provided in **Appendix E**.

Table 8-1 Land Classification

Classification	Area (ac)
Unplatted	1,253

8.3 Fee Calculation

The Kettle Creek Drainage Basin Old Ranch Road Tributary Drainage Basin Planning Study and Master Development Drainage Plan, prepared by JR Engineering April 2001 (Kettle Creek MDDP/DBPS), states that the MDDP/DBPS study area is a closed basin. Developers of the properties within the MDDP/DBPS subbasin study are responsible for construction of the drainage improvements. This existing closed basin area can be seen in **Appendix F**.

For all other undeveloped land, shown in **Appendix E**, developers will have direct access to Kettle Creek, and do not have upstream neighboring properties that will require additional infrastructure with the exception of parcel owned by 260 EB, LLC. All undeveloped property within the Kettle Creek basin will not be required to pay drainage fees and will not be reimbursed for any drainage infrastructure required for development.

After analyzing the parcel of land owned by 260 EB LLC, it is found that a subbasin boundary runs through the middle of the property. Because of this, approximately 47 acres of the 180 total acres will flow onto the Jovenchi-I LLC property to the south. The 260 EB, LLC property will be required to detain their developed flows to historic levels in conformance with drainage criteria. Jovenchi-I LLC will have to accommodate the undeveloped (historic) flows from 260 EB, LLC (see Appendix F). The 260 EB, LLC developed flows will be detained in the proposed Pond 2. If necessary, the owners of 260 EB, LLC and Jovenchi-I, LLC will need to work cooperatively to determine an outfall point for the proposed Pond 2. Furthermore, they may opt to work together to combine Pond 2 and Pond 3 by allowing developed flows to pass through the downstream property and locating the combined pond at the site of Pond 3.

With the anticipated approach of having sub-regional detention for any future development in the Kettle Creek basin within the City of Colorado Springs, it is anticipated that the developed runoff from 260 EB, LLC will not generate enough stormwater runoff to necessitate the Jovenchi-I LLC development to construct reimbursable infrastructure. The remaining 133 acres from the 260 EB, LLC property will be required to detain to historic rates prior to the release onto platted county property.

It is proposed that the study area be considered a closed drainage basin. As a closed basin, development would not be required to pay drainage fees. The landowners/developers will not be reimbursed for the construction of these facilities and thus the financial implications to the City are negligible.

9 REFERENCES

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Appendix A – Stakeholder Meeting Summaries

-No Stakeholder Meetings Required