

Citywide Stormwater Master Plan

City of Steamboat Springs, Colorado

April 2013

Prepared by:

SEH

Prepared for:

City of Steamboat Springs

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April 23, 2013

RE: *City of Steamboat Springs- Citywide Stormwater Master Plan - SEH No. 120556*

Mr. Ben Beall, PE
Project Engineer
City of Steamboat Springs
137 10th Street
Steamboat Springs, CO 80477

Dear Mr. Beall:

SEH is pleased to present the Final Citywide Stormwater Master Plan to you and the staff at the City of Steamboat Springs. The master planning process for the drainage basins within the city limits is thoroughly documented from project initiation through the conceptual design phase. The Citywide Stormwater Master Plan also includes an alternatives analysis, an overall cost evaluation, conceptual design plans for improvements, and an estimate of the capital, operation and maintenance, and water quality costs for the overall stormwater management program.

This report includes a description of the Walton, Burgess, Fish, Fox, Spring, Butcherknife, Soda, Copper Ridge, Pine Grove Road/Mt. Werner Road, and Emerald Mountain/Orton Meadows watershed areas, a pilot scale inventory of the existing stormwater system, the hydrologic and hydraulic analysis for existing and future conditions, and identification of the problem areas. The hydraulic capacities, overall condition, and maintenance condition of the existing stormwater infrastructure studied are also included and discussed in the report.

On behalf of the SEH team, we truly appreciate the opportunity to work with you on this project, and we look forward to assisting you with your future stormwater and civil infrastructure needs.

Sincerely,

E. Danny Elsner, PE
Project Manager

Enclosure

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LIST OF ACRONYMS

AC	Acre
AC-FT	Acre-Foot (Feet)
BMP	Best Management Practice
CDOT	Colorado Department of Transportation
CFS	Cubic Feet per Second
CMP	Corrugated Metal Pipe
CWCB	Colorado Water Conservation Board
CY	Cubic Yard
EA	Each
EPA	Environmental Protection Agency
FEMA	Federal Emergency Management Agency
FES	Flared End Section
FIS	Flood Insurance Study
GIS	Geographic Information Systems
HDPE	High Density Polyethylene
HSG	Hydrologic Soil Group
LF	Linear Foot
LIDAR	Light detection and Ranging
MEP	Maximum Extent Practicable
MS4	Municipal Separate Storm Sewer System
NAD	North American Datum
NAVD	North American Vertical Datum
NRCS	National Resource Conservation Service
O&M	Operation and Maintenance
PCSWMM	Interface for EPA SWMM from CHI Software
PGRMWR	Pine Grove Road/Mount Werner Road
RCBC	Reinforced Concrete Box Culvert
RCP	Reinforced Concrete Pipe
ROW	Right(s)-of-Way
SF	Square Foot (Feet)
SWMM	Storm Water Management Model
UDFCD	Urban Drainage and Flood Control District
USFS	United States Forest Service
USGS	United States Geological Survey
WQCV	Water Quality Capture Volume

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1.0 INTRODUCTION

1.1 Authorization

Short Elliott Hendrickson (SEH) was retained by the City of Steamboat Springs (the City) to complete a Citywide Stormwater Master Plan for the major basins within the City. The Agreement by and between the City of Steamboat Springs, a Municipal Corporation, and Short Elliott Hendrickson, Inc., for "Preparing a Stormwater Master Plan in Steamboat Springs, Colorado" was executed on April 25th, 2012, and authorizes SEH to conduct a Citywide Stormwater Master Plan for the major basins within the City limits.

1.2 Purpose and Scope

The major drainage basins to be evaluated include Walton Creek, Burgess Creek, Pine Grove/Mt. Werner Road, Fish Creek, Fox Creek (Old Fish Creek), Spring Creek, Butcherknife Creek, Soda Creek, Copper Ridge, and Orton Meadows/Emerald Mountain. While Soda, Butcherknife, and Spring Creeks have been studied as part of the 2009 Old Town Drainage Study and Floodplain Masterplan for Soda, Butcherknife and Spring Creeks (the Old Town Drainage Study), the remaining basins have never been studied comprehensively to estimate runoff rates and volumes, to identify drainage conditions and problem areas, and to provide alternative solutions to solve observed drainage problems. The purpose of this Citywide Stormwater Master Plan is to broadly evaluate the existing condition of the stormwater infrastructure, to estimate the peak runoff rates and volumes for each watershed area, and to recommend general solutions to alleviate potential flooding problems. In the remainder of the report, alternatives will be evaluated, costs estimated, and projects prioritized. Operation and maintenance (O & M) costs will also be estimated, as will costs to implement water quality components. The information provided herein will be used to broadly estimate capital and O & M costs that will be used as the basis for pursuing a stable, adequate, flexible, and equitable method for funding a Citywide stormwater management program that includes capital, O & M, and water quality components.

The scope of this Citywide Stormwater Master Plan included evaluation of the existing storm sewer, street, culvert, roadside ditch, and creek capacities; development of hydrology for the 5-, 25-, and 100-year storm events for existing and fully developed conditions; identification of existing and fully developed problem areas; development of alternatives; and a conceptual design that includes a phasing plan and a list of O & M activities such that annual capital and operations costs can be estimated.

Specifically, the following tasks were completed in fulfillment of the Citywide Stormwater Master Plan:

- Collected existing information as directed by City staff, including existing 13th Street and Old Town Drainage studies, existing zoning and future land use estimates, and the City of Steamboat Springs Engineering Standards
- Solicited input from project sponsors and stakeholders
- Collected stormwater infrastructure size, overall condition, and maintenance condition data on a pilot scale for representative drainage areas and extrapolated that data over the remaining areas of the City
- Obtained GIS information, including 2-foot contour mapping, from the City
- Obtained zoning map from the City (used for land use determination)
- Determined sub-basin boundaries and parameters
- Developed existing and fully developed conditions hydrology using PCSWMM
- Evaluated existing, major storm sewer, street, and structure capacities within the watersheds
- Identified broad problem areas and representative needs
- Developed alternatives that include conveyance, detention, property acquisition, water quality, and erosion control
- Established costs for each alternative using the Urban Drainage and Flood Control District unit cost spreadsheets, CDOT unit costs, and costs adjusted to reflect the local Steamboat Springs economy
- Evaluated alternatives quantitatively and qualitatively
- Estimated O & M costs, infrastructure replacement costs, and water quality costs and incorporated into overall recommendation
- Estimated annual capital and maintenance fiscal requirements to establish a stormwater management program with a moderate level of service
- Presented a recommended plan for consideration by the City

1.3 Planning Process

The justification for the creation of a Citywide Stormwater Master Plan is based on the recognition that the City's stormwater management program had never been studied comprehensively, and the fact that known problem areas exist, but had not been quantified. The Old Town Drainage Study identifies problems and needs in the Soda, Butcherknife, and Spring Creek watersheds, but does not include O & M or water quality components. The City wanted a more comprehensive estimate of the overall stormwater problems and needs that included O & M and water quality, and that would provide the basis for stormwater program funding.

A kickoff meeting was held with the City on May 15, 2012 to establish initial priorities and to discuss project status and areas of concern. Meeting minutes for these meetings are included in Appendix D. At the kickoff meeting, the City clarified the overall goals and objectives of the Citywide Stormwater Master Plan to include identification of problem areas, estimation of capital, O & M, and water quality costs, and conceptual design of solutions. The decision was made to consider existing and future conditions because considerable amounts of land are available for development in some watersheds. The City also indicated the need to evaluate the condition of the existing stormwater infrastructure, and agreed that the best approach was to collect detailed size, type, overall condition, and maintenance condition data in representative areas and to extrapolate the results across the other portions of the City. Although the City does not currently own or maintain any regional or sub-regional stormwater detention or water quality ponds, an effort was made to seek out potential City-owned properties to accommodate future regional detention and water quality. Other stakeholders, local residents, and property owners were also encouraged to provide information and to participate in the process to ensure that water quality, recreation, and overall quality of life issues were considered.

1.4 Mapping and Surveys

The City provided GIS topographic data in two-foot contour intervals used for engineering calculations. The 2008 mapping data is tied to the NAVD 88 vertical datum and the NAD 83 horizontal datum, and was used to delineate sub-basins and to calculate areas, lengths, slopes, centroids, and elevations. Additional GIS data of the storm sewer system was obtained that assisted in the delineation of sub-basins and in locating existing infrastructure in the field. The City also provided GIS files of known utilities, parcels, zoning, and street centerlines in the vicinity of the project.

Additional survey data was not required for this project. A level, tape measure, and measuring wheel were used to determine relative elevations, slopes, pipe and culvert sizes, and distances.

1.5 Data Collection

The City was the primary source of data used for this Citywide Stormwater Master Plan. The primary references used for this study are as follows:

1. City of Steamboat Springs, September, 2007. *Engineering Standards – Section 5.0 Drainage Criteria*

2. City of Steamboat Springs, General Services, GIS, *2008 topographic data with 2-foot contours*.

3. Federal Emergency Management Agency, effective February 4, 2005, *Flood Insurance Study, Routt County, Colorado and Incorporated Areas,* Flood Insurance Study Number 08107CV000A.

4. J3 Engineering Consultants, Inc., April, 2009. *Old Town Drainage Study and Floodplain Masterplan for Soda, Butcherknife and Spring Creeks.*

5. Landmark Consultants, Inc., June 5, 2012, *Final Drainage Study for 13th Street Drainage.*

6. U. S. Environmental Protection Agency, March 2008. *Storm Water Management Model, Version 5.0.*

7. U.S. Department of Agriculture, Natural Resources Conservation Services, Survey Area Date, September 25, 2007, *Soil Survey Area: Routt Area, Colorado, Parts of Rio Blanco and Routt Counties.*

8. U.S.G.S., *Analysis of the Magnitude and Frequency of Floods in Colorado*, WRI Report 99-4190, 2000.

9. U.S.G.S., *Guidelines for Determining Flood Flow Frequency, Bulletin #17B*.

10. U.S.G.S., *Program PKFQWin Version 5.2.0*.

11. Urban Drainage and Flood Control District, 2001. *Urban Storm Drainage Criteria Manual – Volumes I, II, and III.*

12. Weatherbase, Routt County, Hayden, Oak Creek, Steamboat Springs, and Yampa, Colorado, July 5, 2001. http://www.weatherbase.com/weather

1.6 Acknowledgements

SEH wishes to acknowledge the various individuals who assisted in the preparation of this Citywide Stormwater Master Plan. City staff provided institutional knowledge, historical records, GIS data, and planning information used to create the hydrologic models, to evaluate alternatives, and to complete this report. The representatives contributing their expertise to this effort are listed in Table 1.

Table 1: Project Participants

Participant Name	Organization	Title
Ron Berig	City of Steamboat Springs, Public Works	Assistant Street Superintendent
Janet Hruby	City of Steamboat Springs, Public Works	City Engineer
Doug Marsh	City of Steamboat Springs, Public Works	Street/Fleet Superintendent
Philo Shelton	City of Steamboat Springs, Public Works	Director of Public Works
Ben Beall	City of Steamboat Springs, Public Works	Public Works Engineer
Mary Schutte	City of Steamboat Springs, General Services	GIS Coordinator
Steve Gardner	Short Elliott Hendrickson	Project Manager
Roger Peterson	Short Elliott Hendrickson	Hydrology and Hydraulics
Danny Elsner	Short Elliott Hendrickson	Project Engineer
Kelly Jankowski	Short Elliott Hendrickson	Design Engineer
Ryan Crum	Short Elliott Hendrickson	Design Engineer
Allison Wolfe	Short Elliott Hendrickson	Design Engineer

2.0 STUDY AREA DESCRIPTION

2.1 History and Location

The City of Steamboat Springs is a home rule municipality that is the most populous city of Routt County, Colorado. According to the United States Census Bureau, the city has a total area of 10.1 square miles and a population of about 12,000 people. Steamboat Springs, at an elevation of approximately 6,732 feet, is located in the upper valley of the Yampa River along U.S. Highway 40 (known as Lincoln Avenue in the City), just west of the Continental Divide at Rabbit Ears Pass.

The Yampa Valley and the City of Steamboat Springs are home to several geothermal hot springs. The city is named after the Steamboat Spring, situated near the library and old train depot. Early settlers thought the spring's bubbling sounded like a steamboat chugging down the Yampa River. Although construction of the railroad silenced the chugging sound in 1908, the name endured, and Steamboat Springs is nationally and internationally known as "Ski Town USA".

The study area for the Citywide Stormwater Master Plan encompasses all of the major basins within the City limits of Steamboat Springs, including Walton, Fish, Fox, Spring, Butcherknife, and Soda Creeks, all of which confluence with the Yampa River. Burgess Creek is a tributary to Walton Creek. The Pine Grove Road/Mt. Werner Road, Copper Ridge, and Emerald Mountain/Orton Meadows watershed areas were also evaluated. The City limits and the broad area studied are shown on the Vicinity Map.

2.2 Major Drainage Basins

The study area includes all of the major drainage basins within the city limits that convey snow melt and stormwater runoff to the Yampa River. With the exception of the Pine Grove Road/Mt. Werner Road, Copper Ridge, Emerald Mountain/Orton Meadows, and Fox Creek watershed areas, the creeks are perennial in nature and generally convey flows from the north and east to the south and west. A brief description of the drainage basins is presented below.

2.2.1 Walton Creek

Walton Creek is the southernmost stream conveying runoff through the study area. The lower reach of Walton Creek passes through the southwest corner of the City, picking up flows from Burgess Creek just south of Walton Creek Road. The Walton Creek watershed is approximately 49.5 square miles, and conveys flows from south to north and northeast to its discharge point in the Yampa River, some 750 feet west of the intersection of Highway 40 (Lincoln Avenue) and Walton Creek Road.

Walton Creek is a perennial stream that impacts residential and commercial properties west of Whistler Road and south of Walton Creek Road. The creek itself is at its widest and deepest through the study area, and is generally described as a rectangular channel with a 20-foot-wide bottom covered with cobbles of varying size and shape, making the channel relatively stable. The depth varies along the channel depending upon the location, and overbank areas are prevalent in this lower reach. As the channel enters the study area from the south, encroachment by development is readily apparent. Just north of Stone Lane, the channel meanders close to the Yampa River Core Trail, passes beneath a pedestrian bridge for the trail, then hugs the northwest shoulder of Chinook Lane. After passing beneath another pedestrian bridge, Walton Creek passes between the La Quinta Inn and single family residences along Willow Brook Court that back to the creek, before finally encountering the box culverts beneath Lincoln Avenue on its way to the Yampa River. The majority of the tributary area contributing runoff to Walton Creek lies in the upper and middle reaches of the basin.

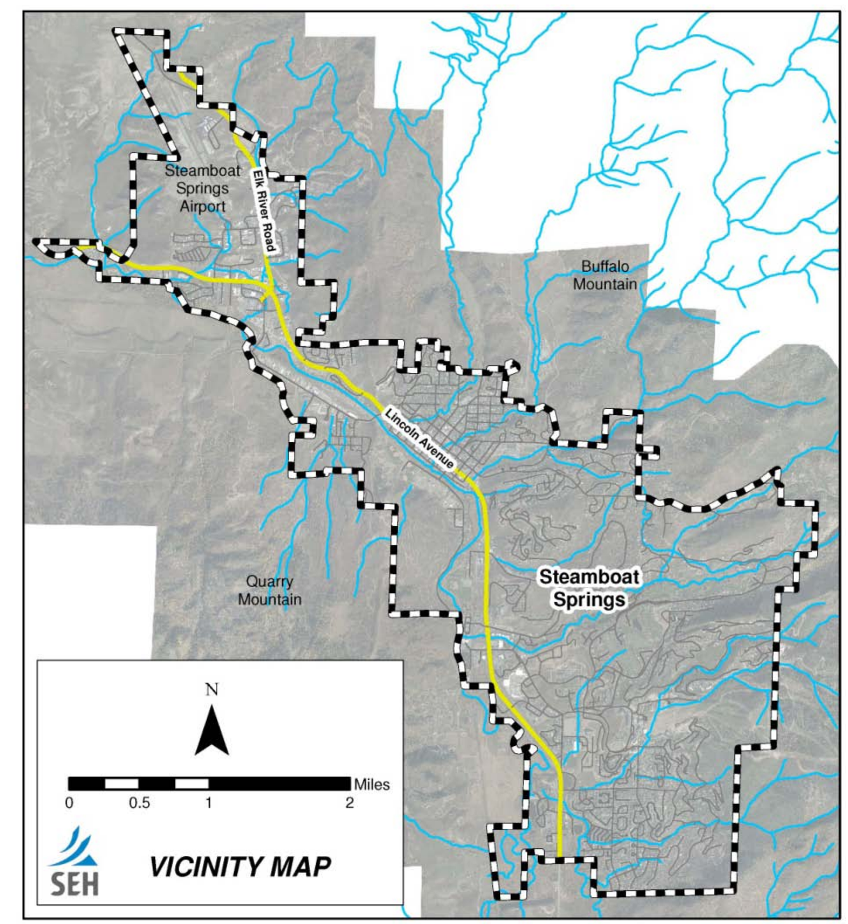
2.2.2 Burgess Creek

Burgess Creek confluences with Walton Creek south of Walton Creek Road, just east of Quality Inn and Suites. Upstream of Walton Creek Road, Burgess Creek is a variable width rectangular channel that varies in depth. The Burgess Creek watershed area is approximately 4 square miles, and conveys flows on a perennial basis through undeveloped land, the Steamboat Springs ski area, and commercial and residential properties from the northeast to the southwest at slopes ranging from 4 to 35 %. Burgess Creek is the basin most heavily impacted by the Steamboat ski area and tourism industry. Significant features include Casey's Pond, the diversion structure just downstream of Ski Time Square Drive, and the downhill ski area.

2.2.3 Pine Grove Road/Mt. Werner Road Watershed Area

The Pine Grove Road/Mt. Werner Road (PGRMWR) basin is a previously undefined and unnamed basin situated just north of the Burgess Creek watershed. One of the smaller basins in the city, the PGRMWR basin's 1-square mile tributary area lies entirely within the City limits, and does not include undeveloped, high mountain areas. Consequently, the watershed carries flows only during periods of snow melt and when stormwater and irrigation runoff conveyance is required. The basin includes multiple crossings of Lincoln Avenue that are used

Vicinity Map



as outfalls to the Yampa River. The slopes within the basin range from 1 to 20%. The main conveyance channel is poorly defined and V- shaped within the upper and middle reaches, then becomes more defined and rectangular in the lower reaches. The majority of the watershed area is served by open channel, but commercially developed areas in the lower portions of the basin and other smaller sub-basins are largely served by roadside ditch and storm sewer, including the sub-basin that includes the Central Park Drive shopping center just downstream of Pine Grove Road. This basin is home to the Yampa Valley Medical Center, a golf course, residential development in the middle reaches, and retail commercial in the lower reaches.

2.2.4 Fish Creek

The Fish Creek watershed shares a southern boundary with the PGRMWR basin. The majority of this long, narrow basin lies upstream of the city limits, with the creek itself serving primarily to convey runoff from the upper and middle undeveloped reaches to the Yampa River. The portion of the basin within the city limits consists of mostly residential and commercial developments contributing runoff to a well-defined, fairly consistent open channel that is approximately 20-30 feet wide in most places and horizontally and vertically stable. Fish Creek is a perennial stream, with a total tributary area of nearly 28 square miles and slopes ranging from 2 to 28 %. Fish Creek crosses Lincoln Avenue between Pine Grove Road and Anglers Drive, flows beneath a railroad trestle, then cuts between Alpine Lumber and a mobile home park before discharging to the Yampa River.

2.2.5 Fox (Old Fish) Creek

The Fox Creek watershed is only slightly larger than the PGRMWR watershed at 1.3 square miles, but this intermittent stream conveys snow melt and runoff through primarily residential and commercial development. The creek itself is largely a natural, undefined channel of varying widths and depths at an average slope of about 9%. The lower reaches appear to be impacted by development and private property. Key features include Rita Valentine Park, and the Fox Creek trail with its arched crossing beneath Hilltop Parkway. Development is on-going within the basin. Although there are 3 crossings of Lincoln Avenue within the basin, the primary crossing occurs at Trafalgar Drive, while the other 2 minor crossings are located near Old Fish Creek Falls Road. The railroad track serves as an obstruction to the local runoff west of Lincoln Avenue, and influenced the location of the existing outfalls to the Yampa River that converge at the first railroad bridge crossing the Yampa River near Snake Island.

2.2.6 Spring Creek

Spring Creek shares a basin boundary with Fox Creek, and is impacted by the historic Old Town Steamboat Springs area. The majority of the 8.3 square mile watershed area is in the upper reaches, well above the city limits. The perennial creek conveys snow melt and runoff from the undeveloped upper reach past Steamboat Springs High School, beneath Oak Street and Lincoln Avenue, and into a 9-foot by 5-foot RCBC that outfalls to the Yampa River along the 3rd Street alignment. Within the study area, Spring Creek displays a rectangular and trapezoidal cross section for low flows and a relatively wide overbank floodplain area. Open channel bottom widths range from 6 to just over 20 feet. Slopes in the basin range from 1 to 21 %, but that includes the upper reaches which are considerably steeper than the reach that passes through the City.

2.2.7 Butcherknife Creek

Butcherknife Creek is a perennial stream that cuts through the heart of the historic Old Town Steamboat Springs area. The tributary area is approximately 3.5 square miles, with slopes that range between 0.9 and 14 %. The channel is defined, but varied in cross section, as development over the years has encroached upon the channel with fill, retaining walls, and other structural means intended to protect private property from overflow. The floodplain is very shallow and spreads out where flow backs up at crossings, confined areas, and obstructions. The channel is laterally stable because it is largely confined by landscape and retaining walls throughout most of the study area reach. Vertical stability is provided by the natural cobblestone channel bottom. The open channel portion of Butcherknife Creek ends about ½ block southwest of Oak Street, where a 54-inch RCP conveys flows beneath private property and Lincoln Avenue. The open channel resumes just upstream of the Ghost Ranch Saloon, crosses under Yampa Street in twin 60-inch RCPs, and outfalls to the Yampa River in an open, u-shaped channel on the south side of Yampa Street between 6th and 7th Streets.

2.2.8 Soda Creek

Soda Creek is a 26.6 square mile watershed that includes the north section of the historic Old Town Steamboat Springs. The stream carries snow melt and stormwater runoff on a year-round basis through primarily residential and commercially developed properties to its confluence with the Yampa River just upstream of the Bud Werner Memorial Library. Within the City Limits, Soda Creek is a rectangular channel that is typically 15-25 feet wide with a varying depth. The channel bottom is relatively stable and is comprised of a cobble stone bed in most places, but is exposed bedrock at the severe bends just upstream of Yahmonite Street near 9th Street. Lateral stability is enhanced by the encroachment of private properties into the floodplain, but the limited channel capacity in restricted areas causes discharge over the banks in some locations.

2.2.9 Copper Ridge Basin

The Copper Ridge basin area is located at the north end of the City, and is made up of 3 square miles of watershed area that is largely undeveloped. Conveyance in the developed portions of the watershed is largely open channel/roadside ditch and storm sewer. Slopes within the basin range from 1 to 28 %. The basin is rapidly developing, especially along Elk River Road toward Copper Ridge Circle, and in the area southwest of Lincoln Avenue and Elk River Road, where the development activity is primarily commercial. Older residential areas exist west of Downhill Drive and south of Lincoln Avenue. The Riverside Drive residential area is impacted by both snowmelt and stormwater runoff because it is situated in a low-lying area between Lincoln Avenue and the Yampa River.

2.2.10 Emerald Mountain/Orton Meadows Basin

The Emerald Mountain/Orton Meadows Basin is situated on the south side of the Yampa River, between the 13th Street bridge on the southeast and the James Brown Soul Center of the Universe bridge on the northwest. The lower portions of the basin are almost entirely commercial/industrial northeast of 13th Street. The middle portions of the basin, situated southwest of 13th Street, are a mix of commercial and residential properties. The upper reaches of the basin are primarily established residential and large lot ranchette properties. Slopes in the basin range from 1 to 14%. The basin area is slightly larger than 2 square miles.

2.3 Climate

Steamboat Springs enjoys warm days and cool nights in the summer months, and cold, snowy winter months. Based on the Flood Insurance Study for Routt County, the majority of annual precipitation occurs as snow throughout the winter and deep snowpack accumulates as elevation increases. Precipitation varies with elevation in the area. The normal annual precipitation ranges from 24 inches along the Yampa Valley floor to approximately 80 inches in the high mountain peaks. Average annual snowfall typically averages 13 feet per year in Steamboat Springs. A typical winter begins with the first snowfall in October, and snow begins melting in

April and, depending on the depth of snowpack, continues through June and into July. 14 inches of snow is the equivalent of 1 inch of precipitation.

2.4 Soil Information

As expected, more than one hydrologic soil group (HSG) is represented in the watersheds that are within the City limits. According to the National Resource Conservation Service (NRCS), HSG B, C, and D soils can be found in the study area, the majority of which is HSG B and C. To be conservative, and to be consistent with the Old Town Drainage Study, Type C soils were assumed throughout the study area. Although Type D soils are prevalent in the Copper Ridge and Fish Creek basins, the infiltration parameters are the same from a hydrologic perspective. In general, HSG B soils are identified as having medium runoff potential and moderate infiltration potential, while HSG C soils have medium to low infiltration rates and moderate to high runoff potential. Type D soils have slightly lower infiltration rates, swell potential, and high to severe runoff potential.

2.5 Flood History

The Steamboat Springs area has a history of flooding that dates back nearly 100 years. The Flood Insurance Study for Routt County and Incorporated Areas (FIS) discusses a number of historical flooding events that were primarily a combination of snowmelt and rain storms that created swollen creeks attempting to drain to the Yampa River that was already at or near capacity, resulting in safety issues and property damage. The spring of 2011 served as another strong reminder of the potential for flood damages after a near record winter for snowpack depth combined with a warmer-than-average spring and spring rains resulting in swollen creeks and existing storm sewer systems that had no place to discharge collected stormwater. In late April, a heavy, wet snow blanketed the City when drainage infrastructure was already heavily impacted by spring runoff. In the Emerald Mountain/Orton Meadows basin, existing infrastructure was unable to convey the volume of runoff and snowmelt, and flood depths of several inches were observed across the northwest end of 13th Street. The commercial building at 2005 13th Street was flooded with several inches of water. In early June, low-lying parcels situated adjacent to the confluence of Walton Creek and the Yampa River were adversely impacted by flood waters. Access roads serving commercial properties from US40/Lincoln Avenue were rendered impassible, with over 2 feet of water submerging the access to the Steamboat Hotel and Majestic Valley subdivision. Access to the Shell Gas Station and the USFS office building at Weiss Drive was also adversely impacted. Rotary Park was inundated, and water crept onto Mt. Werner Road near the Lou Gabos Bridge and railroad crossing. In addition to 2011, the FIS also reports other significant rain events as summarized below:

June, 1921: "Flooding was widespread in the region in 1921, with highway travel cut off and towns isolated. In Steamboat Springs, flow in Soda Creek was too great to be passed by the Lincoln Avenue crossing, and a large lake formed that surrounded several homes and was backed up by the bridge. Floodwater ultimately flowed over the street in a stream that was a half-block wide, the bridge was damaged and the stream bank eroded. Between Lincoln Avenue and the Yampa River, Soda Creek was from 300 to 500 feet wide. The measured stage of the Yampa River in Steamboat Springs indicated a flow of 7,000 cfs, which was 1,000 cfs greater than any flow of record. Flow in Soda Creek was estimated at 2,000 cfs."

April, 1974: "…all streams in the Steamboat Springs area were higher than at any other time in recent history, but damage occurred principally along Butcherknife Creek. Three days of unseasonably warm weather (which accelerated snowmelt) and a heavy rain triggered flooding that began at 6 p.m. on April 25 and lasted until midnight April 27. Flooding of disastrous levels along the Yampa River and Fish Creek was prevented by 200 to 300 volunteer floodfighters who filled and placed sandbags and built emergency berms at critical locations. However, approximately 50 homes along Butcherknife Creek were surrounded by floodwater, and approximately 300 homes were threatened. A state of emergency was declared on April 26. Flow in the river was approximately 500 cfs above flood stage."

The important components of the history of flooding in Steamboat Springs that are found in the FIS are:

- The major flood events in the city have been a result of the combination of high snowmelt runoff and convective thunderstorms;
- The probability of flooding from local, intense, convective thunderstorms is high in Steamboat Springs and the surrounding area;
- Shallow, overland flooding is very likely to occur within Steamboat Springs during major storm events or during storm events that coincide with spring runoff because of insufficient capacity of existing streams and channels, homes built in close proximity to existing streams, and obstructions within flooded areas such as roadway culvert crossings with insufficient capacity;
- The 100-year storm results from the combination of snowmelt and thunderstorm events;
- The 500-year flood on the Yampa River is created by a frontal storm event; and
- The 500-year flood on the creeks tributary to the Yampa River results from a convective thunderstorm event.

Research and discussions with residents and business owners in proximity to the drainageways within Steamboat Springs confirm that flood hazards exist. Development encroached upon most of the creeks in the city limits before floodplain regulations were adopted to protect people and property from flooding. The degree of risk depends largely upon location within each watershed, and each watershed presents different levels and frequency of flood risk.

2.6 Preliminary Problems and Needs Assessment

One of the primary goals of this master planning effort is to identify the problems and needs of the existing stormwater infrastructure and management program such that a basic cost estimate for addressing the needs and shortcomings can be developed. This section outlines the overall issues and challenges in the City, and provides additional details regarding specific problems and needs within each watershed area. The issues, problems, and needs were identified and discussed at several progress meetings with City staff and discovered during field investigations. Homeowners, business owners, and other stakeholders were also interviewed to gain as much insight as possible into the cause, duration, and severity of each problem.

Problems and needs maps, showing the location and general type of problem, are included in Appendix A. Photos and a brief description of each issue are included. The infrastructure impacted, the photos, and the issues are catalogued for inclusion in the City's GIS. A sample of the drainage infrastructure from the watersheds within the City was also inventoried to assist in the estimate of the backlog for remedial maintenance and future capital improvements. The size, construction material, maintenance condition, and overall condition were recorded, and photos were taken to memorialize the data.

2.6.1 Overall Problems and Needs

The City of Steamboat Springs is facing a variety of problems and needs at the physical level and the program level. Problems and Needs are presented in Appendix A for each individual basin. While the program level issues are largely beyond the scope of this master plan, the physical problems and needs are broadly outlined below:

- Aging drainage infrastructure, much of which is in need of replacement immediately, or within 5-10 years.
- Drainage and flooding problems that are major challenges for individual property owners to solve.
- Lack of regularly scheduled, routine maintenance on most of the stormwater system, except on a primarily reactive basis.
- Storm sewers and outfalls clogged with silt, sediment, debris, and trash; outfall locations are silted in and buried by vegetation and overgrowth.
- Runoff from upstream development adversely impacting downstream properties.
- An unfunded Federal mandate to protect water quality per the Phase II MS4 stormwater quality permit enforced by the State.
- During snowmelt and storm events, the water surface elevation in the Yampa River gets high enough to create a backwater effect at the majority of the watershed outfalls; many of the existing outfall systems are full before a storm event begins, resulting in a smaller conveyance volume for the runoff generated by a storm event.
- Inadequate storm sewer and channel capacities to convey 100-year storm events without creating a backwater effect and/or overtopping banks.
- Development that occurred before regulations and criteria were in place has encroached upon flood conveyance channels and floodplains, causing flooding of homes, businesses, property, and infrastructure.
- The majority of the major drainageways lie within private property, and the City does not have easements along the major drainageways to enable maintenance, repairs, major rehabilitation, or routine monitoring of unauthorized floodplain encroachments except under enforcement of code compliance.
- High groundwater levels associated with spring snowmelt significantly reduce the capacity of the existing stormwater conveyance system.
- During winter months of shallow snowpack, ice dams often form at inlets and culverts, resulting in unsafe conditions for drivers and pedestrians, as well as elimination of conveyance capacity in the spring. Spring storm events have caused structure and property flooding because of ice dams.
- Currently, new development does not adequately share in the cost to improve the regional stormwater infrastructure beyond the boundaries of their development site.

2.6.2 Walton Creek – Problems and Needs

- Flooding problems exist at the corner of Whistler Road and Skyview Lane.
- According to eyewitnesses, the outlet pipe for the on-site detention pond for the Holiday Inn backs up when the water surface elevation in Walton Creek reaches a certain stage, filling the detention pond beyond its capacity and flooding the parking lot; other potential causes for the Holiday Inn parking lot flooding include a backup of the US40 roadside ditch conveyance system. Overflow from the roadside ditch finds its way through the parking lot to the detention pond. Cars have floated away and damage has been reported.
- Quality Inn and Suites, as well as a number of single family residential homes along Willow Brook Court are in close proximity to the Walton/Burgess Creek confluence and at risk for flood damages.
- The culvert conveying flows beneath Meadow Lane along the Bear Creek tributary is undersized for the 100-year storm, creating the potential for overtopping, piping around the culvert, and eventual washout of the roads.

2.6.3 Burgess Creek – Problems and Needs

- Existing triple 48-inch culverts beneath the Walton Creek Trail at the confluence with Walton Creek are too small to pass the 100-year flow without overtopping and creating backwater.
- Existing trees and vegetation are restricting the capacity of the triple 48-inch culverts beneath the Walton Creek Trail at the confluence with Walton Creek.
- Existing 48-inch culvert crossing at Walton Creek Road is undersized for the 100-year storm event and deteriorating rapidly.
- The Burgess Creek channel is undersized for the 100-year storm event and in dangerous proximity to the commercial structure at the southeast corner of Village Drive and Apres Ski Way.
- The engineered channel and diversion structure built in the 1990s just downstream of Ski Time Square Drive is too close to the condominium structure, creating a scenario for potential flooding of lower condo units in large storm events.
- Erosion and headcutting is evident upstream of Ski Time Square Drive through the Kutuk Condominium complex.

2.6.4 Pine Grove Road/Mt. Werner Road Basin – Problems and Needs

- Flow capacity and path are undefined at the soccer fields of the recreation center; a detailed inventory is recommended at a future date to determine the path that stormwater takes to reach the Yampa River.

- Flow path and capacity is estimated as runoff approaches Rockies Way and Mount Werner Road – more detailed information is needed in this area to determine how flows cross Mt. Werner Road.

- Drainage patterns and existing infrastructure need more study at Central Park Drive and Pine Grove Road; existing infrastructure for crossing Pine Grove Road appears inadequate to convey the 100-year storm event.

2.6.5 Fish Creek – Problems and Needs

- During the 2011 spring snowmelt and flooding event, residents of the Fish Creek Mobile Home Park used sandbags to slow the encroachment of Fish Creek and the Yampa River onto various properties within the park; according to anecdotal accounts, the railroad crossing backed up, causing flows to divert north to Angler's Drive, and through the park. Some properties were reportedly damaged.

- The railroad crossing, the commercial crossing between Safeway and Starbucks, and the Rollingstone Lane bridge are all likely unable to convey the 100-year storm event; backwater effects could threaten private and commercial properties.

2.6.6 Fox Creek (Old Fish Creek) – Problems and Needs

- Groundwater seeping out of the hillside along High Pointe Drive collects just east of the intersection with Lincoln Avenue, creating a nuisance hazard in the summer and an icing issue in the winter.

- Minimal conveyance options are available as Fox Creek approaches Hilltop Parkway/Lincoln Avenue; options are needed to convey flows to the Yampa River.

- Portions of the Fox Creek trail beneath the arched culvert at Hilltop Parkway have eroded away because of overflows from the low flow channel.

- Private property owners have constructed unapproved minor structures and potential barriers to flow in Fox Creek, creating flood hazards.

2.6.7 Spring Creek – Problems and Needs

Problems and needs have been previously discussed in the Old Town Drainage Study and Floodplain Masterplan for Soda, Butcherknife and Spring Creeks (see Reference 4). The following includes many of the observations included in the Old Town study, as well as our indications of the problems and needs.

- Hydraulic capacities at private and public pedestrian bridges and decks should be checked for backwater effects that could adversely impact adjacent properties and infrastructure.
- The triple 54-inch CMPs conveying Spring Creek beneath Amethyst Drive need maintenance to clear sediment, debris, and vegetative growth to ensure maximum capacity.

2.6.8 Butcherknife Creek – Problems and Needs

Problems and needs have been previously discussed in the Old Town Drainage Study and Floodplain Masterplan for Soda, Butcherknife and Spring Creeks (see Reference 4). The following includes many of the observations included in the Old Town study, as well as our indications of the problems and needs.

- Higher water surface elevations from backwater effects occur at the confluence with the Yampa River because of the slightly upstream orientation of the outfall for Butcherknife Creek.

- The retaining wall for the right bank of the outfall channel is in need of repair or replacement.

- According to the Old Town study, the masonry culvert conveying Butcherknife Creek below Lincoln Avenue is undersized for the 100-year storm; the culvert is identified in the City's GIS as a 54-inch RCP.

- The confined nature of Butcherknife Creek creates the potential for flooding the properties that have encroached upon Butcherknife Creek over time.

- City staff has provided sand bags and assistance to residential and commercial property owners during spring snowmelt and storm events to minimize damage to structures.

- The majority of the culvert crossings beneath roadways are undersized for the 100-year storm event and in poor overall and maintenance condition.

- Many of the retaining walls that confine the channel are deteriorating and in need of repair or replacement.

2.6.9 Soda Creek – Problems and Needs

Problems and needs have been previously discussed in the Old Town Drainage Study and Floodplain Masterplan for Soda, Butcherknife and Spring Creeks (see Reference 4). The following includes many of the observations included in the Old Town study, as well as our indications of the problems and needs.

- Left and right bank erosion is prevalent near Little Toots Park near the Bud Werner Library; the crude, concrete block retaining wall along the right bank also appears to be deteriorating and is in need of repair or replacement.

- Upstream of Lincoln Avenue, the right bank is showing signs of moderate to severe erosion.

- The retaining walls upstream of Lincoln Avenue are deteriorating and need to be repaired or replaced.

- The roadway culvert crossings at 11th Avenue and Oak Street and Pahwintah Street are undersized for the 100-year storm event.

- Pine Street and Yahmonite Street culvert crossings have recently been replaced to pass a moderate storm event, but may not be sized to pass the 100-year storm event.

2.6.10 Copper Ridge Basin – Problems and Needs

- The roadside ditch serving S. Copper Passage, the private drive just east of the CAT Rental center on Copper Ridge Drive, gets flooded on a routine basis because of inadequate capacity, slope, and maintenance.

- Many of the single-family residences in the Riverside subdivision are constructed lower than the road serving them, and several are in the path of runoff.

- The drainageway for Copper Ridge is constricted by commercial property and single-family residences on Honeysuckle Lane, creating the potential for overtopping and property damage.

2.6.11 Emerald Mountain/Orton Meadows Basin – Problems and Needs

- During the spring of 2011, several commercial properties experienced 6- to 12 inches of flood water above their finish floor elevations.

- The basin is extremely flat, with very little vertical relief along 13th Street between Shield Drive and Gilpin Street.

- The 30-inch CMP outfall pipe that passes beneath the Union Pacific Railroad tracks was observed to be below the water surface elevation of the Yampa River in May, 2012, a year considered to be an average or below average spring runoff year.

- Alluvial groundwater levels rise during the spring snowmelt, reducing infiltration, filling up roadside ditches and pipes, and eliminating conveyance options for stormwater runoff.

- Anecdotal accounts of street and property flooding exist in the historic Brooklyn neighborhood as a result of flat terrain and minimal maintenance.

3.0 HYDROLOGIC and HYDRAULIC ANALYSIS

3.1 Overview

SEH performed a hydrologic analysis for all of the major drainage basins in Steamboat Springs to estimate the peak runoff discharge and characteristics of each basin. The hydrologic analysis provides the framework for determining deficiencies in infrastructure capacity, defining drainage and water quality problems and needs, and for estimating costs associated with addressing the problems and needs.

Peak discharges for the 5-, 25-, and 100-year return period storms were analyzed using PCSWMM, a program which combines EPA SWMM 5.0 and GIS, to generate hydrographs for each sub-basin. Hydrographs for the sub-basins were routed using PCSWMM to determine peak discharge rates at select design points. Results at key design points were then compared to existing stream gauge data, where possible, to ensure reasonable results were generated. For Spring, Butcherknife, and Soda Creeks, peak discharge rates were calibrated to closely match peak discharge rates generated in the Old Town Drainage Study and Floodplain Masterplan for Soda, Butcherknife, and Spring Creeks. In general, peak discharge rates generated using PCSWMM were reasonably close to the peak discharge rates outlined in the Old Town study before calibration.

Although snowmelt runoff impacts the stormwater system, an evaluation of snowmelt runoff was not included in the plan to be consistent with the hydrologic analyses included in the Old Town Study. In addition, order of magnitude calculations were performed that suggested the snowmelt runoff would be equivalent to a 5-10 year storm event, which is far less than the runoff generated by the 100-year storm event. Using the 100-year storm event as the benchmark provided a more reliable way to estimate costs associated with improvements and to form the basis for improved stormwater funding.

3.2 Previous Studies

With the exception of the Old Town study that focuses on Spring, Butcherknife, and Soda Creeks, and a master planning study for the Base Area/Whistler Meadows by Civil Design Consultants, no previous comprehensive hydrologic studies have been performed on the major drainage basins within the City. The FEMA FIS provides general hydrologic information and history about some of the major basins, but analyses are limited to estimates of peak discharges based on regression equations. The previous studies that have been completed focus on providing design parameters for localized areas in support of bridge or culvert replacements, storm sewer infrastructure sizing, and land development activities. The Final Drainage Study for 13th Street Drainage is an example of a study that SEH reviewed as part of the scope for this master plan to gain insight into the information that has already been published.

3.3 Design Rainfall

Based on Figures RA-1 through RA-6 in the UDFCD Criteria Manual and Table 5.5.1 of the City of Steamboat Springs Engineering Standards, the 1-hour and 24-hour rainfall precipitation depths, shown in Table 2, were input into the PCSWMM to model the watershed hydrology for each storm event. Following a discussion with City staff, the 1-hour precipitation depths were included to reflect the convective nature of the majority of the storm events experienced in Steamboat Springs. The 1-hour precipitation depths were input into CUHP 2005 to obtain a 2-hour distribution curve for input into PCSWMM.

Table 2: Point Rainfall Values for Steamboat Springs (inches)

Reoccurrence Interval	1-Hour Precipitation Depth	24-Hour Precipitation Depths
5-Year	0.78	1.7
25-Year	1.09	2.4
100-Year	1.46	2.8

3.4 Basin Delineation

The 10 major drainage basins within the City of Steamboat Springs, as well as the Yampa River, were delineated based on the 2-foot contour GIS mapping provided by the City. Walton, Burgess, Fish, Spring, Butcherknife, and Soda Creeks were delineated. In addition, several basins were delineated and evaluated based on their significant contribution to drainage problems and needs within the City, including the PGRMWR basin (situated between Burgess and Fish Creeks), Fox Creek (Old Fish Creek, between Fish and Spring Creeks), a basin that SEH refers to as Copper Ridge, and the Emerald Mountain/Orton Meadows basin. The basins range in size from one square mile (PGRMWR) to nearly 50 square miles (Walton Creek). The PCSWMM input is in Appendix B. The watershed delineation map is also included as Figure 2 – Basin Map.

3.4.1 Sub-basin Delineation

Each watershed was divided into sub-basins based on the 2-foot contour GIS mapping provided by the City of Steamboat Springs, and verified through field observations. The sub-basins range in size from less than one acre to just over 75 acres, with an average sub-basin size of approximately 20 acres. The sub-basin flow paths and slopes were determined using the City of Steamboat Springs topographical mapping in GIS. Sub-basins were divided based on dominant flow paths that are largely dependent upon slopes. Sub-basins were examined to ensure that the shape factors reasonably satisfied PC SWMM parameters.

3.4.2 Watershed Imperviousness

The majority of the basin areas within the City limits is developed, with a few notable vacant parcels primed for future development in the Copper Ridge, Emerald Mountain/Orton Meadows, Fox, PGRMWR, and Burgess Creek basins. The City of Steamboat Springs' most recent GIS zoning map layer, their aerial photography and topography, and site observations were used to estimate the sub-basin imperviousness. The existing and future land use maps are shown on Figures 3 through 22. Impervious values and land use descriptions associated with each land use type are located in Table 3, and are based on the percent impervious values for each land use type shown in Table 5.6.3 - Recommended Impervious Values presented in the City of Steamboat Springs Engineering Standards. Figures 23-32 depict the existing hydrologic conditions, including the subbasin ID, area, and percent impervious values, for each subbasin identified. Future condition hydrologic conditions are displayed in Figures 33-42.

Table 3: Land Use Descriptions

Land Use Type	Description	Impervious Value (%)
CC	Community Commercial	95
CO	Commercial Old Town	95
CS	Community Services	95
CY	Yampa Street Commercial (Adjacent to Lincoln Alley)	95
CY	Yampa Street Commercial (Adjacent to the Yampa River)	85
CI	Commercial Neighborhood	85
G-1	Gondola One	85
G-2	Gondola Two	85
I	Industrial	85
MF-1	Multi-Family One, Low Density	50
MF-2	Multi-Family Two, Medium Density	60
MF-3	Multi-Family Three, High Density	75
MH	Mobile Home	41
OR	Open Space and Recreation	5
PL	Paved Lot	100
RC	Recreation Center	75
RD	Railroad	15
RE-1	Residential Estate One, Low Density	25
RE-2	Residential Estate One, Medium Density	40
RN-1	Residential Neighborhood One, Low Density	25
RN-2	Residential Neighborhood Two, Medium Density	40
RN-3	Residential Neighborhood Three, High Density	45
RO	Residential Old town	45
RR-1	Resort Residential One, Low Density	70
RR-2	Resort Residential Two, High Density	80
UD	Undeveloped	2

3.4.3 Depression Losses

Depression losses were determined using Table RO-6 in the UDFCD Criteria Manual. A pervious depression loss of 0.35 inches and an impervious depression loss of 0.1 inch were used for all watersheds.

3.5 Hydrograph Routing

The parameters for the PCSWMM model conveyance elements were determined using the City of Steamboat Springs GIS contour data for channel and street sections and GIS storm sewer data for storm sewer elements. The model's input parameters and 100-year fully developed output are included in Appendix B.

The major drainage basins were assigned alphanumeric characters unique to each basin, and subbasins were given consecutive numeric designations as outlined below:

- WA – Walton Creek
- BU – Burgess Creek
- PG – Pine Grove/ Mount Werner Basin
- FI – Fish Creek
- FX – Fox Creek
- SP – Spring Creek
- BK – Butcherknife Creek
- SO – Soda Creek
- CR – Copper Ridge
- EM – Emerald Mountain/ Orton Meadows Basin

Existing detention facilities, inadvertent detention, and retention storage were not accounted for in the hydrologic analysis because the majority of these facilities are privately owned and maintained, and cannot be consistently relied upon as functioning components of the drainage system. Storm sewer capacities were estimated using normal depth. When the storm sewer capacity is exceeded, the remaining flow is conveyed overland and by streets.

3.6 Hydraulic Analysis

Routing the peak flows generated by each subbasin through the major drainage basin with reasonable accuracy requires estimates of conveyance properties for each conveyance element used in the model. The majority of streets in Steamboat Springs convey stormwater through adjacent roadside swales or ditches, and a standard street/ditch cross section was used to estimate conveyance capacities. Open channel flow calculations using Manning's Equation and the FlowMaster software were required to evaluate open channel capacities, and CulvertMaster was used to evaluate capacities of existing culverts and to estimate the size of necessary culverts. Storm sewer lines were modeled such that they are assumed to flow full at normal depth with the remaining flow being conveyed overland via street systems. Inlets were not evaluated as part of this study. Flow routing in the model is performed for the peak flows, and takes inadvertent storage, the time it takes flows in sub-basins to make it to each design point, and other factors into consideration. As a result, flows along the major drainage flowpath are not always additive.

Table 4 summarizes the Manning's n values that are used in the conveyance elements for the PCSWMM model.

Table 4: Manning's n Values Used for Conveyance Elements

Conveyance Element	Manning's n Value	
	Main Channel	Banks
Street	0.01875*	0.0625*
Channel	Varies	Varies
Storm Sewer (RCP)	0.013	
Storm Sewer (CMP)	0.024	
Storm Sewer (HDPE)	0.018	

*To compensate for increased viscosity and energy losses caused by debris and sediment transport in the flow, roughness coefficients for all channels in the model were adjusted until the Froude number of the channel for the 100-year event equals one or less.

3.7 Results of Hydrologic Analysis

PCSWMM output can be found in Appendix B. A summary of key peak flows is listed below in Table 5.

The calculated peak discharges in the PCSWMM were carefully examined for reasonableness through a comparison to available data and previous studies. The discharges were compared to flood peak estimates from historic flood events, an analysis of stream gage information (where available), regional regression equations, and previous studies. Precipitation data from the Western Regional Climate Center and recent reports of flooding due to snowmelt from the Colorado Water Conservation Board (CWCB) were consulted. SEH also reviewed a number of newspaper accounts of flooding in Steamboat Springs.

Although stream gauge information is available at two separate locations on the Yampa River, data from these gauges cannot be relied upon to establish peak flood estimates. The size of the Yampa drainage area is too large for data to be extrapolated to the much smaller basins and subbasins in Steamboat Springs. In addition, the timing for the flood peaks from the basins and subbasins vary with each storm event, making the gauge data on the Yampa irrelevant without stream gauge and detailed precipitation information from each of the local subbasins. There are, however, 3 stream gauges that have operated over various time periods in the study area that provide the best estimate of expected flood peaks from basins within Steamboat Springs. These gauges include Station 08238500 Walton Creek near Steamboat Springs, 08238800 Fish Creek at Upper Station near Steamboat Springs, and Station 0823940 Spring Creek near Steamboat Springs with contributing areas of approximately 42, 26, and 7 square miles, respectively. The gauge information was analyzed using Program PKFQWin Version 5.2.0, distributed by the USGS, and that analyzes gauging data using the methods recommended in Guidelines for Determining Flood Flow Frequency, Bulletin #17B, Interagency Advisory Committee on Water Data, systematic peaks, and systematic frequency. In addition, the stream gauge data was analyzed using Log Pearson Type III Analysis. Regional regression equations, developed by the USGS, were also used to estimate flood peaks at the stream gauges.

Finally, published information from FEMA for Burgess, Butcherknife, Fish, Soda, and Spring Creeks were examined for this effort. FEMA used a regression analysis for flood peak estimates for these streams. The results of the J3 Engineering Report for the Old Town drainage study were also compared to this study. SEH also met with representatives of the NRCS and Upper Yampa Water Conservancy District in Steamboat Springs, but neither organization offered applicable information for this study.

Based on our broad comparison, the regulatory discharges published by FEMA generally represent the highest flowrates (with the exception of Burgess Creek), and are used in this study to calibrate the drainage basins with regulatory floodplains. Basins and subbasins not included in the FEMA FIS with a significant contributing area were calibrated to produce a discharge of about 116 cfs per square mile, consistent with the stream gauge data collected. Model results for Butcherknife, Spring, and Soda Creek compare favorably with those presented in the Old Town study.

Table 5: Peak Flow Comparison for Select Locations

Basin	Location	Basin Area (acres)	FEMA 100-Year (cfs)	Existing 100-Year (cfs)	Future 100-Year (cfs)	Future 100-Year Detained (cfs)	Future 25-Year (cfs)	Future 5-Year (cfs)
Walton Creek	Walton Creek at Yampa	31654	1980	1819	1829	1788	952	599
Burgess Creek	Burgess Creek at Walton Creek Road	2585	400	812	955	784	605	416
PGRMWR Basin	PGRMWR at Yampa	627	N/A	425	538	N/A	381	251
Fish Creek	Fish Creek at Yampa	17869	1800	1529	1642	N/A	748	583
Fox Creek	Fox Creek at Yampa	822	N/A	608	657	465	473	310
Spring Creek	Spring Creek at Yampa	5312	650	653	653	575	446	307
Butcherknife Creek	Butcherknife Creek at Yampa Street	2250	325	320	320	165	216	137
Soda Creek	Soda Creek at Yampa	16993	1300	1383	1383	495	1088	726
Copper Ridge	Elk River Road at Lincoln	1869	N/A	373	445	330	308	203
Emerald Mountain/ Orton Meadows	At west end of 13th Street	1389	N/A	232	271	N/A	170	108

3.8 Results of Hydraulic Analysis

3.8.1 Evaluation of Existing Facilities

Hydraulic analyses were performed to evaluate the capacity of the existing channels, culverts, and storm sewers. The storm sewer and culvert capacities were determined using Manning's equation with information gathered from the City of Steamboat Springs' GIS data. Storm sewer pipes were assumed to flow full. Where storm sewer and roadside ditches are present, total conveyance capacities assume allowable street/ditch capacities are reached, with the balance of the flow carried by the storm sewer or RCBC.

In general, the existing channels and storm sewers making up the major flowpath are located in the low points within each sub-basin, but are only sized for the 2- to 5-year storm event. The overall age of the existing stormwater system is 15 to 30 years, and most of the system was installed before the City of Steamboat Springs adopted drainage criteria. Although the condition of the entire system was not comprehensively evaluated, many of the existing storm sewer outfalls that are visible from the ground appear to be in fair to poor condition, depending upon pipe material. Inverts for CMP are generally in poor condition or are non-existent and need to be on a replacement schedule. Culvert crossings beneath roadways are consistently undersized for storms greater than the 5-year event. Many of the culverts beneath Lincoln Avenue/US40 have 100-year capacity or greater.

3.8.2 Flood Hazards

The majority of the flood hazards in the City's watershed network are a result of overflows when creek, culvert, storm sewer, and roadside ditch capacities are exceeded. Spring storm events are the worst because much of the capacity in the existing drainage system is being used by snowmelt. As a result, the storm drainage system becomes overwhelmed, and runoff either inundates properties adjacent to the creek or street ROW or results in shallow street flooding as runoff finds its way to the major drainageway through adjacent streets or properties.

In general, the existing channel, roadside ditch, and storm sewer capacities limit stormwater conveyance to less than the 2- to 5-year storm event. Several of the major drainageway conveyance culverts beneath Lincoln Avenue, however, are sized for the 100-year storm event. A summary of the existing culvert and storm sewer capacities is included in Appendix C. The Alternatives Analysis focuses on meeting City of Steamboat Springs criteria where possible, and investigates methods to alleviate flooding through a combination of channel improvements, roadside ditch expansions, and storm sewer/street conveyance and detention options. Although inlets were not analyzed as part of this plan, new inlets meeting City of Steamboat Springs criteria were included in the cost estimates for all alternatives, largely because the existing inlets are reaching the end of their service lives in the majority of the watershed areas.

3.9 Field Inventory

To achieve a better understanding of the condition of the infrastructure, and to construct a more detailed estimate of the backlog, SEH performed a field sampling of several hundred existing stormwater conveyance structures, including the major drainageways, roadside ditches, storm sewers, and culvert crossings, selected to be representative of the various ages and types of structures. Data was collected on structure type, approximate age, overall condition, maintenance condition, and estimated cost to rehabilitate, and photos were taken to obtain a visual understanding and to document our findings.

The “pilot scale” inventory was conducted primarily to estimate the cost to repair and update the stormwater infrastructure without performing a detailed, time- and labor-intensive full-scale inventory. Pilot scale inventories have been completed for several other local governments in Colorado with much success, and are regularly used as a first step in estimating costs for replacement and rehabilitation of infrastructure when establishing a stormwater utility. The data collected for the pilot scale inventory associated with this project was extrapolated across each basin to produce a range of costs for replacement and rehabilitation. These costs are explained in Section 5.0 and included in the cost estimating tables in Appendix C.

The results of the field inventory are displayed in Appendix A - Problems and Needs. Based on the results of the inventory, and an analysis of the City’s GIS data, the following highlights are presented:

- The stormwater conveyance system within the City’s jurisdiction is presently made up of approximately 30 miles of creek/channel, 30 miles of underground storm sewer pipe, and about 100 miles of roadside ditch.

- The majority of the creeks/channels do not have the capacity to convey the 100-year flowrate for fully developed conditions, and very little capacity for expansion of the creeks exists because development has already encroached upon the floodplain.

- The majority of the storm sewer is corrugated metal pipe (CMP) that is 10-20 years old, with a life expectancy of less than 30 years. Based on our assessment, approximately 10% of the storm sewer needs immediate replacement; 20% is in need of major rehabilitation; and 20% should be replaced within the next 5-10 years.

- Roadside ditches are typically undersized, have not been routinely maintained, and have clogged driveway culverts.

4.0 ALTERNATIVE ANALYSIS

4.1 Alternative Development Process

The process for developing and evaluating potential alternatives for solving the identified problems and reducing flood hazards was determined by evaluating conveyance and detention options by watershed, and by considering the technical feasibility and constructability of each option within each watershed. Because the majority of the watersheds have already experienced significant growth, other important considerations included available land for easement and ROW acquisition, location, type, and size of existing utilities, and the potential for future development and re-development in each basin. Conveyance, detention, property acquisition, and water quality options were evaluated against these parameters to identify preliminary alternatives that were then analyzed to determine their hydraulic impacts, costs, and potential benefits. Each alternative also underwent a qualitative screening process to identify intangible benefits and potential drawbacks. Special consideration was given to evaluate potential solutions to known flood hazards. Finally, a recommended alternative was selected that encompassed the most tangible and intangible benefits for the least overall cost.

4.2 Criteria and Constraints

Because of the physical constraints that are present within each basin, practical solutions to flood hazard problems are limited to upsizing existing storm sewers, roadside ditches, and culverts, and potentially introducing regional detention and/or new storm sewer conveyance in select areas. Water quality BMPs with a focus on sediment and nutrient removal/reduction are possible, especially in areas where regional detention is considered. Because of the high groundwater table during the spring months, water quality BMPs that focus on volume reduction through infiltration are probably not worth consideration on a large scale.

Discussions with the project stakeholders provided guidelines for establishing initial alternatives that included an open channel and storm sewer conveyance system that meets current City of Steamboat Springs criteria (i.e. 100-year conveyance); a combination of regional detention and 100-year conveyance; and an optimization of the existing storm sewer system. Optimization considers what can be improved in the system to use as much of the existing system as possible, while improving the overall conveyance capacity of the system to at least the 5-year storm event. All three alternatives include taking advantage of opportunities to incorporate permanent BMP water quality enhancements wherever possible. For all analyses, future conditions were considered with respect to estimated flowrates and anticipated runoff volumes. Storm sewer capacities were calculated using full flow conditions, and no surcharge was permitted. For all alternatives, existing inlets are replaced with Type 16 inlets sized to ensure that the inlets are not restricting flow and that the storm sewer capacity is the limiting factor. The regional detention alternative using newly acquired ROW is sized to accommodate the 100-year storm event using allowable 100-year release rates without consideration for sediment accumulation.

4.3 Alternative Categories

The major alternative categories that were considered for the watersheds in Steamboat Springs are conveyance, detention, property acquisition, and water quality. For each basin, the alternatives considered (either individually or combined) are listed in Table 6, Alternatives Pre-Screening Matrix.

Table 6: Alternatives Pre-Screening Matrix

Description	Alternative Evaluated	Basin									
		WA	BU	PG	FI	FX	SP	BK	SO	CR	EM
100-Year Storm Conveyance without Regional Detention	Improve channel, storm sewer, and roadside ditch conveyance to safely convey the 100-Year storm event	X	X	X	X	X				X	X
100-Year Storm Conveyance with Regional Detention	Construct regional detention to reduce peak flows and to limit the need for upsized channel or storm sewer	X	X			X	X	X	X	X	
Stormwater System Optimization	Improve existing channel, storm sewer and roadside ditch conveyance system to convey the largest practical storm event	X	X	X	X	X	X	X	X	X	X
Property Acquisition	Purchase property to reduce or eliminate flood hazards							X			
Water Quality	Include Water Quality Capture Volume (WQCV) in new regional detention ponds; encourage low impact development (LID) BMPs for all new and re-development; construct sub-regional water quality ponds	X	X	X	X						
Erosion Control	Channel improvements and protection at storm sewer outfalls		X	X		X		X	X		
No Action	Maintain existing conditions	X	X	X	X	X	X	X	X	X	X

4.4 Alternative Hydraulics

Following the channel, storm sewer and roadside ditch capacity estimations, opportunities for incorporating regional detention and water quality were examined. Initially, potential detention pond locations were screened based on locations of existing open space and parks, and in a few cases, undeveloped properties in the upper portions of each watershed. Each pond location was evaluated to estimate the potential detention volumes based on rough estimates of the area available and reasonable estimated pond depths. Because of limitations associated with the relatively steep terrain, and the fact that development has encroached upon many of the properties that would be conducive to locating a detention pond, only a limited number of new locations were found with the potential to significantly reduce peak flows. Each detention pond location was incorporated into the PCSWMM to evaluate its effectiveness on reducing peak flows in the system. Detention had no impact on the 100-year peak flow in Pine Grove/ Mount Werner Road, Fish Creek, and Emerald Mountain basins and therefore these basins were not evaluated for Alternative 2. Fox Creek, Butcherknife Creek, Soda Creek and Copper Ridge basins experienced a peak flow reduction of twenty five percent or greater at the major basin outfalls. It is recommended that detention be further evaluated in these four basins when considering implementing detention as location and size of detention may have a better or worse impact on peak flow reduction. Refer to Figure 43 for approximate detention pond locations as evaluated in PCSWMM.

Storm sewers were sized to accommodate stormwater flows in excess of roadside ditch capacities after regional detention ponds were evaluated, optimized, and included in the PCSWMM. For the 100-year conveyance options (with and without regional detention), RCPs were evaluated to ensure pipe longevity, reduced maintenance, and adherence to City of Steamboat Springs street capacity criteria. The Stormwater System Optimization option sized RCPs for approximately the 5-year storm event, keeping feasibility, cost, and other intangible constraints in mind.

4.5 Alternative Costs

The construction costs for each alternative were estimated using unit costs obtained from the UDFCD UD-MP COST spreadsheet data and adjusted for the Steamboat Springs area. Easement and land acquisition costs were also estimated using the UDFCD UD-MP COST spreadsheet data, and adjusted upward for Steamboat Springs area market conditions. Unit costs can be found in Table 7. Costs for utility relocation, contingencies, engineering, legal, and administration were included as a percentage of construction as follows:

Utility Relocation	5%
Contingencies	25%
Engineering Design Services	15%
Legal and Administrative Services	5%
Construction Administration and Management	10%

Storm sewer quantities were based on proposed alignments using the LIDAR mapping and GIS from the City of Steamboat Springs. It was assumed that all inlets would be replaced with standard City of Steamboat Springs Type 16 inlets. The number of manholes necessary to complete the improvements is minimal considering the majority of the storm conveyance system consists of culverts and open channels and ditches. Therefore, the cost of manholes and junction boxes are included in the linear foot costs for storm sewer. Outfall protection riprap was estimated based on an average culvert diameter of 60-inches for the 100-year event and 42-inches for a 5-year event and an estimated depth of two feet.

Regional and water quality pond grading was estimated based on LIDAR mapping, assuming one foot of freeboard above the required detention/water quality volume. Land acquisition costs include surveying and document preparation for easements, but land acquisition is assumed to be at no cost to the City for those ponds located on City open space and/or park property. Erosion and sediment control BMPs are included in the estimates to ensure compliance with current City of Steamboat Springs requirements.

Summaries of costs for each alternative are shown on the tables opposite each corresponding alternative plan sheet in Appendix C. Each summary of costs includes utility relocation, contingencies, engineering design services, legal and administrative services, construction administration and management, and land acquisition.

Table 7: Unit Costs

Item	Unit	Unit Cost
18" RCP	LF	$86
24" RCP	LF	$115
30" RCP	LF	$144
36" RCP	LF	$173
42" RCP	LF	$201
48" RCP	LF	$230
54" RCP	LF	$259
60" RCP	LF	$286
Twin 48" RCP	LF	$460
66" RCP	LF	$315
72" RCP	LF	$491
78" RCP	LF	$533
Twin 60" RCP	LF	$573
Twin 66" RCP	LF	$630
Triple 60" RCP	LF	$859
12'x6' RCBC	LF	$1,615
12'x8' RCBC	LF	$1,781
Twin 10'x5' RCBC	LF	$2,528
Twin 10'x6' RCBC	LF	$2,788
Twin 12'x6' RCBC	LF	$3,230
Twin 12'x8' RCBC	LF	$3,563
Triple 10'x8' RCBC	LF	$4,609
Type 16 Inlet	EA	$3,825
Buried Riprap	CY	$65
Regional Detention		
Detention	AC-FT	$50,000
Water Quality		
Water Quality Pond	AC-FT	$50,000
Grass-lined Swale+	LF	$100
Porous Landscape Detention+	AC-FT	$435,600
Porous Pavement+	SF	$15
Land Acquisition		
Land Acquisition*	AC	$35,000-$1.2M

*Land acquisition costs based on property location and current real estate values

4.6 Alternative Plans

This section provides a graphic summary of the 100-year alternative with and without regional detention for each basin based on the alternatives considered and summarized in Table 6: Alternatives Pre-Screening Matrix. Alternative 1 evaluates the drainage infrastructure required to accommodate the 100-year storm event without detention. Alternative 2 evaluates the drainage infrastructure necessary to accommodate the 100-year storm event with regional detention. Alternative 3 seeks to optimize the existing system with upgrades to drainage infrastructure required to pass at least the 5 year storm event. Because the Old Town study includes detailed alternatives analyses for the Soda, Butcherknife, and Spring Creeks, alternatives analyses for those creeks are not included in this plan. The figures in Appendix C present a plan view of the generic components for each alternative, with estimated costs provided on the back of each figure for all three alternatives (where applicable). The following subsections describe the goals of the alternative evaluation process and the evaluation criteria used to consider each alternative.

4.6.1 Alternative Evaluation Goals and Criteria

Development of alternatives included consideration of goals and criteria to guide the alternative evaluation process. The goals included:

- Protect the public and property from flood hazards and damages by reducing the flooding risks
- Minimize stream instability, including degradation and aggradation
- Enhance the recreational and environmental amenity that is the Yampa River by encouraging water quality improvements in the tributary watersheds
- Include maintenance as a routine function and factor costs into alternatives
- Be mindful of the pending changes to the MS4 Phase II water quality permit

Other evaluation criteria include:

- Constructability and construction costs
- Implementation
- Impacts to property owners and the community
- Future impacts to land use and development
- Sustainability

4.6.2 Special Water Quality Concerns

The City of Steamboat Springs is currently a Phase II MS4 Water Quality Permittee, and must comply with the six (6) minimum measures as spelled out in the MS4 permit. The United States Environmental Protection Agency (EPA) has been considering national changes to the MS4 program that include five (5) rulemaking actions that have a potential significant fiscal impact to existing MS4 permittees. The draft national rulemaking document is likely to be presented in Spring, 2013, with final rulemaking and implementation scheduled for 2015. The highlights of these potential changes are presented below.

- The EPA is considering instituting numerical standards for stormwater treatment, requiring MS4 permittees to sample, test, and show compliance with numeric standards or limits. Currently, MS4s are held to standards that simply use Best Management Practices to reduce pollutants to the Maximum Extent Practicable, or MEP;
- Broader approaches to expanding the land areas covered by MS4 permits is also being considered, including options such as county-wide and watershed-based permitting, that would greatly expand coverage boundaries and require additional land use authority and police powers to enforce;
- The current MS4 permit only requires stormwater quality BMPs for new and re-developments. The EPA is exploring options for requiring existing development (that development already in place before the original MS4 permit was issued) to retrofit stormwater quality BMPs into their site plans that might include permeable pavements, rain gardens, sand filters, bioswales, and even green roofs. This retrofit requirement could cost $10,000 - $20,000 per acre, and would be an unfunded mandate to be complied with by the City of Steamboat Springs as an MS4;
- The EPA is also evaluating the possibility of establishing one set of minimum measures for all regulated MS4s, potentially requiring that Phase II permittees such as the City of Steamboat Springs would be required to do all of the functions that Phase I permittees (i.e. large municipalities in expansive urban areas) have to do. These Phase I requirements include wet weather sampling of all storm sewer outfalls to receiving waters; and
- Finally, the EPA is considering options for establishing specific requirements for transportation facilities such as CDOT, which could have an impact on the City because of US40/Lincoln Avenue.

The combination of these potential changes to the current MS4 permit for the City of Steamboat Springs could result in significant fiscal impacts. While these rulemaking efforts are being drafted by the EPA for permittee comments in 2013 and are not certain, the potential for greater emphasis on stormwater quality is present and must be accounted for in stormwater master planning. This master plan takes these potential changes into account, and includes costs for future implementation.

4.6.3 Property Acquisition Considerations

Properties with known flooding problems or increased flood risks should be evaluated for potential purchase. Assuming a willing seller, acquiring properties at risk from flooding is an industry accepted practice that has many quantitative and qualitative advantages. Although the initial capital cost is relatively high, the benefits typically outweigh the costs if risks are analyzed conservatively over a long period of time. This alternative is only viable when combined with other alternatives, as other uses for the acquired property (i.e. detention, water quality, or a park) must be considered.

4.6.4 Qualitative Evaluation

In addition to evaluating the estimated costs, water quality concerns, and potential property acquisition associated with each alternative, several other qualitative aspects of each alternative were weighed to round out the evaluation process. The following qualitative aspects contributed to the alternatives analysis:

- Feasibility of Construction
- Integration with Existing Infrastructure
- Mitigation of Problem Areas
- Level of Flood Protection
- Public Safety
- Potential to Leverage Funding
- Multi-use Opportunities
- Environmental Remediation Issues
- Coordination Issues
- Potential for Re-development
- Existing and Surrounding Land Uses
- Water Quality
- Aesthetics
- Potential Utility Conflicts
- Permitting Requirements

The ability to design and construct improvements associated with an alternative is the most important aspect of the qualitative evaluation. Assuming that alternatives are constructible, the other qualitative aspects influence, but do not unilaterally dominate, the evaluation process that leads to providing a recommended alternative. For this alternatives analysis, the qualitative aspects listed above were combined with the costs and other quantitative aspects of each alternative to select the recommended alternative explained below.

4.7 Recommendations

Based on the parameters explained in this section, SEH recommends Alternative 1: The 100-year conveyance alternative. This alternative provides flood protection, minimizes flood risks, and costs less than the 100-year conveyance with detention alternative, largely because of the costs associated with acquiring private property to accommodate detention ponds. We recommend that more detailed outfall systems planning be undertaken for each individual basin after a dedicated funding source is selected. This recommendation is based on conservative estimates for improvements that are accurate enough to provide the framework for establishing a dedicated funding source for an improved stormwater management program. Further analysis is needed to better quantify ditch and channel improvements necessary to safely convey the 100-year event, given any local constraints.

5.0 CONCEPTUAL DESIGN

5.1 Plan Development Overview

The selected plan provided in this report satisfies the goal of establishing baseline costs for a dedicated stormwater program funding source. The recommendation is to plan for the implementation of Alternative 1 – 100-year conveyance. The recommended plan was chosen based on a broad range of input from project sponsors, stakeholders, and the public, using estimated costs, and a qualitative evaluation matrix. The selected plan represents the best overall solution for the City given the existing constraints and considering the numerous intangible benefits that are not directly quantifiable. The selected plan meets the following principal elements, goals, and objectives:

- Identifies representative problems and needs for each basin.
- Minimizes stormwater runoff and flood-related damages to major drainageways, public infrastructure, and private property, to the maximum extent practical at this stage of funding development.
- Provides improved stormwater conveyance, while encouraging re-development in areas vital to the City of Steamboat Springs.
- Considers the need for new and upgraded roadway crossings and open channel conveyance improvements.

5.2 Plan Description

Conceptual design plans have been prepared for the selected plan and are located in Appendix C. Figures C-1 through C-7 show plan drawings for the proposed culverts and culvert crossings. Sizes and costs are shown in the corresponding Tables C-1 through C-7 in Appendix C.

In summary, the recommended plan for all of the basins evaluated mitigates the potential flooding problems in the major drainageway by increasing the capacity of culverts and swales. Water quality may also be enhanced through the addition of grass-lining and check structures to open channel conveyance structures within the major drainageway. The total estimated costs for improvements are included in Appendix C.

<u>Walton Creek</u>

Starting at the top of the basin, existing culverts beneath Val d'Isere Circle are upgraded from 36-inch CMPs to 36- and 42-inch RCPs to fully convey the 100-year storm. The existing culverts at the crossing above the existing pond between Hunter's Drive and Apres Ski Way are being upsized from 4-24-inch CMPs to twin 48-inch RCPs, and the crossing at Meadow Lane is being upsized to a 72-inch RCP. The recommended plan also includes upsizing the existing 72-inch CMP in Bear Creek that conveys flows from approximately Sequoia Court down to just beyond Cedar Court. As long as routine maintenance is performed on the twin 60-inch CMPs beneath Chinook Lane, these pipes have the capacity to convey the 100-year storm event. Other highlights include upsizing the existing 24-inch CMP beneath Chinook Lane at Skyview Lane to a 42-inch RCP, as well as the existing 24-inch CMP beneath Chinook Lane that is 500 feet northwest of Skyview Lane to a 54-inch RCP. To prevent backwater entering the existing on-site detention ponds and parking lot inlets, check or reed valves should be installed on the outfall pipes that discharge to Walton Creek.

<u>Burgess Creek</u>

Culvert replacements in this basin begin above Storm Meadows Drive along Burgess Creek Road. The Burgess Creek crossing at Burgess Creek Road requires twin 48-inch RCPs. At Storm Meadows Drive, the existing 48-inch CMP is replaced by a 72-inch RCP or equivalent. The 4-foot by 7-foot RCBC beneath Ski Time Square Drive is adequately sized to convey the 100-year storm event without overtopping, but the driveway crossing within the Kutuk Condominiums and the next driveway crossing upstream require upsizing to 72-inch RCPs. The combination of the existing 78-inch CMP and the new open channel through the Steamboat Ski area should be adequate to convey the 100-year storm event, but costs were included in the estimate to upsize the storm sewer conveyance should that become necessary with the updated hydrology. Triple 60-inch RCPs or equivalent are recommended to convey 100-year flows beneath Apres Ski Way, through the commercial property, and beneath Village Drive. Detention was evaluated at the open area between Eagle Ridge Drive and Village Drive and was found to be moderately effective. Costs for detention are included in Alternative 2 for Burgess Creek. The newly replaced 66-inch by 96-inch arched CMP culvert at Eagle Ridge Drive has the capacity to convey the 5-year event, but a 12-foot by 6-foot RCBC is required to fully convey the 100-year storm event. The triple 60-inch CMPs that were recently installed beneath Owl Hoot Trail with the Casey's Pond subdivision need to be upsized to accommodate the updated hydrology to twin 10-foot by 5-foot RCBCs. Finally, the existing 48-inch CMP conveying flows beneath Walton Creek Road should be replaced by twin 10-foot by 5-foot RCBCs. Open channel conveyance capacity should also be enhanced along the major drainageway.

<u>Pine Grove Road/Mt. Werner Road Basin</u>

Recommended improvements along the major flowpaths within this basin begin with the replacement of the existing 36-inch CMP beneath Clubhouse Drive with a 42-inch RCP. The 36-inch CMP beneath Steamboat Boulevard is scheduled to be replaced by a new 54-inch RCP, while a 78-inch RCP is required to convey the 100-year storm event beneath Old Mt. Werner Road/Mt. Werner Circle. The triple 48-inch CMPs at Bangtail Way should eventually be replaced with twin 66-inch RCPs. More investigation is required to size the infrastructure required to convey flows through and across the recreational fields south of the tennis pavilion. Additional investigation is also required at the intersection of Central Park Drive and Pine Grove Road to determine the infrastructure required to convey the 100-year storm event. The Lincoln Avenue crossings within this basin are also recommended to be replaced with larger diameter RCPs as shown in Table C-3 in Appendix C.

<u>Fish Creek</u>

The existing 36-inch CMP beneath Steamboat Boulevard should be replaced by a 54-inch RCP. The upper culvert crossing on Meadowbrook Circle should be a 54-inch RCP to replace the existing 36-inch CMP, and the existing lower 18-inch CMP culvert crossing should be replaced by a 60-inch RCP. The existing 10-foot by 9-foot RCBC crossing at Lincoln Avenue is adequately sized to convey the 100-year storm event, even with the updated hydrology presented in this study.

<u>Fox (Old Fish) Creek</u>

Conceptual design highlights in this basin begin with the upsizing of existing 36- and 24-inch CMPs beneath Fish Creek Falls Road and Harwig Circle with 42-inch RCPs. Further downstream, the culverts beneath the private drive off of Angler's Drive should be upsized to twin 48-inch RCPs. Just upstream of Hilltop Parkway, detention was evaluated within the existing Rita Valentine open space and reduced peak flows at the outfall by roughly thirty percent. The existing arched culvert crossing at Hilltop Parkway is more than adequate to convey the 100-year storm event. At the driveway crossing off of Hilltop Parkway just east of Lincoln Avenue, a 78-inch RCP is required in place of the existing 72-inch CMP. To convey flows beneath Lincoln Avenue, and across the commercial property, a series of storm sewers ranging in size from 72-inch RCP to twin 66-inch RCPs or equivalents are required.

Although use of the area just upstream of the Hilltop Parkway crossing was ineffective for detention, the area should still be considered for a future water quality pond or wetland pond. Other opportunities for water quality include wetland diversion channels along the major drainageway.

The nuisance drainage issue at the intersection of High Point Drive and Lincoln Avenue will require a 36-inch RCP to convey flows from the roadside swale on the east side of High Point Drive beneath the access to the commercial property on the south. The existing 24-inch CMP beneath Lincoln Avenue has the capacity to convey the 100-year storm event, but more information is required regarding the overall condition of the pipe before a replacement can be recommended.

Multiple crossings of Lincoln Avenue exist between Fish Creek Lane and Trafalgar Drive/Hilltop Parkway to convey flows from small sub-basins and roadway runoff from the east side of Lincoln to the west side. Of these crossings, most appear to have the conveyance capacity for the 100-year storm event with the exception of the crossing at Fish Creek Lane. This existing 36-inch CMP should be replaced with a 48-inch RCP. The other crossings should be evaluated for overall condition and included on a replacement schedule.

Spring, Butcherknife, and Soda Creeks

The Old Town Drainage Study outlines the recommended improvements for these basins. As indicated in the Old Town Drainage Study, many improvements are needed within the Butcherknife Creek basin, and property acquisition should be a consideration as a long term solution to the problems and needs facing this basin. SEH conceptually evaluated detention for these basins within the limits of the scope and recommends consideration of detention for Butcherknife and Soda Creeks, as detention appears to be beneficial in these basins. Further analysis of these basins is necessary to determine the impact of detention on the recommended improvements included in the Old Town Drainage Study.

Copper Ridge Basin

The existing culverts upstream of the south leg of Copper Ridge Drive have the capacity to convey the 100-year storm event. At the south leg of Copper Ridge Drive, the existing 30-inch CMP needs to be replaced with twin 48-inch RCPs, as does the existing 48-inch CMP crossing of Elk River Road. Detention was evaluated at the Northeast corner of Elk River Road and Copper Ridge Circle, the east corner of Elk River Road and Lincoln Avenue (this pond is existing), and in the open area south of the Whitehaven Court cul-de-sac. Detention was effective at the Elk River Road locations. Because they are not currently publicly owned and maintained, however, the effects of detention were not considered, and full 100-year conveyance was assumed for downstream infrastructure sizing. The series of existing storm sewers conveying flows beneath Lincoln Avenue at the intersection of Elk River Road, across Shield Drive and Curve Court, and to the outfall to the Yampa River generally lack the capacity required to convey the future 100-year storm event and need to be upsized. The RCBC beneath Lincoln Avenue has 100-year capacity for existing runoff, but is slightly undersized for the future 100-year flowrates. The open channel south of the Riverside Plaza property is in need of maintenance and channel improvements. Water quality outlet structures should be included in the design for the detention pond at Elk River Road and Copper Ridge Circle, and should be a retrofit at the existing pond at Elk River Road and Lincoln Avenue.

Emerald Mountain/Orton Meadows Basin

Improvements in this basin begin on Manitou and Saratoga Avenues in the residential portion of the basin. Although the hydraulic evaluation of the existing culvert crossings indicated that capacity was not an issue, the problems and needs/pilot scale inventory assessment showed that the culverts need to be replaced because they are in poor overall condition. Without exception, the existing culverts along 13th Street at intersections with streets and driveways need to be upsized. Most notably, the existing 30-inch CMP outfall to the Yampa River, which is in poor overall condition, needs to be more than doubled in size to a 72-inch RCP to convey 100-year undetained flows. Achieving cover on a pipe of this size, while maintaining hydraulic capacity will present design challenges. Detention was evaluated, but did not demonstrate any hydrologic impact and therefore was not considered from a hydrologic viewpoint. Detention should still be a consideration from a water quality standpoint. This master planning study should be used as the basis for estimating costs associated with addressing the problems in the basin, recognizing that many of the recommended storm sewer improvements will require further research and a detailed basin-wide study after a funding mechanism is in place.

5.3 Prioritization and Phasing

Constructing the infrastructure required at major roadway crossings in the lower portions of each basin will have the largest impact on each watershed. However, each component in the selected plan will provide incremental benefits to the watershed if constructed alone, and will help to solve localized problems and needs. The tables in Appendix C include a column labeled "Priority" that ranks each drainage infrastructure component from 1 to 5 based on the following criteria:

1 – Infrastructure is undersized and also needs to be replaced because of structural deficiencies.

2 – Infrastructure is structurally compromised, but is sized correctly.

3 – Infrastructure is structurally sound, but is sized inappropriately, and requires maintenance. Maintenance could uncover potential issues that were not discovered by the field inspection/pilot scale inventory.

4 – Infrastructure requires maintenance. Maintenance activities could uncover potential issues that were not discovered by the field inspection/pilot scale inventory.

5 – Size and quantity of infrastructure is unknown or was not field inspected as part of the pilot scale inventory.

In general, the recommended prioritization of the conceptual design plan components is as follows:

1. Replace the existing 48-inch CMP beneath Walton Creek Road with the recommended 10-foot by 5-foot twin RCBCs. Downstream conveyance issues must be handled with private property owners at the time of final design. Schedule construction of remaining Burgess Creek improvements to coincide with roadway, water, sewer, and other infrastructure projects to leverage funds.
2. As part of the capital program, begin setting aside funds and programming the acquisition of properties impacted by Butcherknife Creek as they become available for purchase. Establish a dialogue with affected property owners to clearly state and communicate the intentions of the City.
3. Install check or reed valves on the outlet pipes of on-site detention ponds and outfall pipes that have been adversely impacted by high water levels in the Yampa River and that have created backwater problems in the past.
4. Land acquisition and conversion of existing detention/water quality pond areas in the Copper Ridge basin. This improvement will have a measurable flow rate and water quality impact on the stormwater system right away, even without the new outfall piping in place.
5. Further evaluate detention options in the Emerald Mountain/Orton Meadows basin, and begin final design on the conceptual improvements recommended in this study.
6. Construct improvements to solve the nuisance drainage issue at High Point Drive and Lincoln Avenue.

The remaining improvements may be designed and installed at any time, but careful consideration should be given to programmed street and utility projects to leverage funds and maximize efficiency.

5.4 Cost Estimate

Capital costs were estimated based on the hydrologic and hydraulic modeling performed with PCSWMM. A range of costs was developed for the major drainage components necessary to convey the 100-year flow through culverts beneath roadways and within open channels to the Yampa River or other major outfall point. Costs for the rehabilitation and/or replacement of the additional components of the drainage system, including storm sewers and outfall energy dissipation structures, inlets, and minor swales, were estimated through the pilot scale inventory. Representative samples of the drainage system were examined for overall and maintenance condition to estimate rehabilitation/replacement costs of the small sample, then costs were extrapolated across the remainder of the basin under the assumption that the drainage systems in other portions of the basin are in similar overall and maintenance condition as the representative sample.

Water quality costs were estimated assuming additional inspections, sampling, testing, and monitoring requirements will be instituted by the EPA and State. Water quality costs are for the initial 5-year permit term following the announcement of the stricter standards, that are expected to take effect in 2013.

Operation and maintenance costs are estimated based on broad assumptions that include a low to moderate level of service. All components of the drainage system would be cleaned and fully inspected every 8 years. An in-house crew of 2 or 3 would be available full-time during the summer months to remove sediment and vegetative growth from roadside swales, culverts, pipes, outfalls, and inlets in high priority maintenance areas and following storm events. The crew would be available for water quality and storm event inspections, but would not perform water quality sampling or testing because of the stringent sampling and testing protocols anticipated with the upcoming stricter EPA regulations.

Updated cost estimates by basin are presented in Appendix C. A summary of capital costs is found in Table 8 below.

Table 8: Summary of Capital Costs

	Alternative 1	Alternative 2	Alternative 3
Walton Creek Basin	$724,000	$9,415,000	$218,000
Burgess Creek Basin	$3,002,000	$6,651,000	$1,198,000
Pine Grove/ Mount Werner Basin	$2,947,000	$2,947,000	$2,054,000
Fish Creek Basin	$184,000	$184,000	$87,000
Fox Creek Basin	$1,688,000	$2,991,000	$1,003,000
Copper Ridge Basin	$1,657,000	$7,966,000	$858,000
Emerald Mountain/ Orton Meadows Basin	$383,000	$383,000	$293,000
Spring, Butcherknife and Soda Creeks (From Old Town Study)	$7,872,043	$7,872,043	$7,872,043
	$19,000,000	**$39,000,000**	**$14,000,000**

The overall costs associated with operating a stormwater program include administrative costs, engineering, maintenance, water quality (including MS4 compliance), capital project costs, and remedial project costs (pilot-scale inventory needs). While the costs for provision of administrative costs (i.e. overhead items such as facilities and billing costs) were not included in the scope, a summary of the range of overall costs is presented below:

Table 9: Summary of Overall Stormwater Program Costs

Immediate Maintenance Needs	$250,000 - $1,000,000
Water Quality/MS4 Permit Compliance	$1,000,000 - $2,000,000
Capital Costs	$14,000,000 - $39,000,000
Remedial Costs (from Pilot Scale Inventory)	$7,000,000 - $11,000,000
Total Estimated Cost Range	$20,000,000 - $50,000,000
Annual Operation and Maintenance Cost	$200,000

The range of costs for Alternative 2 is high because of the cost of property acquisition in certain areas of the City. Unit costs for property acquisition were estimated based on the 2012/2013 average cost per square foot of developed property according to recent local real estate information found on Zillow.com. A $35,000 to $1.2M range of property acquisition costs is used in this report based on the location of the potential detention. Undeveloped property in some areas of the City is valued at about $35,000 per acre, while highly desirable property near the ski area is valued much higher. Regional detention is likely not feasible in every basin because of high property values in basins located near the ski area. Regional detention should still be considered for basins where use of City-owned property is viable or in areas where property values are lower. The overall estimated cost for a stormwater program that incorporates Alternative 1, recommended by SEH, is approximately $30,000,000, noting that further input on level of service of the above items will alter this cost.

5.5 Operations and Maintenance

Stormwater infrastructure performs the function of removing runoff from streets, highways, parking areas, and property and protects facilities and vital infrastructure from the adverse impacts of flooding. In order for the drop inlets, drains, culverts, pipes, roadside swales, detention, and water quality facilities to function as designed and constructed, they must be properly maintained. Lack of maintenance is a common reason for flooding problems and infrastructure failure. The types of maintenance associated with stormwater management are routine, remedial, and capital improvements.

5.5.1 Routine Maintenance

Routine maintenance includes those activities that are performed on a periodic basis, which may be deemed necessary by the passage of time and not the specific deterioration of the overall stormwater system. Routine maintenance activities include the following:

- Ensuring that drainageways, culverts, pipes, and storm inlets are free from accumulated debris, sediment, and vegetation.
- Correcting failing or malfunctioning components of the system; settlements, breaks, and physical damage are the most common types of failure.
- Anticipating problems and making minor modifications to optimize system performance.
- Ensuring that detention facilities have not suffered a decrease in storage volume because of accumulated sediment and debris, and that outlet structures are not clogged.

The routine cleaning and minor repairs of drainage system components often require that labor intensive hand methods be used. Adequate access for maintenance personnel and equipment to reach the site and perform work on the system should be provided for in the design of the drainage component. The entire drainage system should be inspected at least annually, and during or immediately following storm events to confirm that satisfactory conditions exist, or to evaluate the need for clean-up and repair. As illustrated in Figures A-1 through A-10, a yellow square symbolizes the locations that should be checked on a regular basis according to pilot-scale inventory data, conversations with maintenance personnel, and anecdotal evidence supplied by the public.

5.5.2 Remedial Maintenance

Remedial maintenance repairs and corrects deficiencies in the existing stormwater system without upgrading the capacity of the system. Although a system may be deficient in its overall capacity, remedial maintenance ensures that the system operates optimally. Figures A-1 through A-10 identify the known locations with a yellow square and red dot where remedial maintenance is required based on the modeling data and the pilot scale inventory results. Figures A-1 through A-10 show only those locations that were investigated or modeled as part of this master plan. Additional locations requiring remedial maintenance may exist that may be uncovered as part of a full scale drainage infrastructure inventory.

5.5.3 Capital Improvements

Capital improvements are required to replace deficient or undersized stormwater drainage systems with new, larger, and improved components. The recommended capital improvements are identified as a red dot in the locations shown in Figures A-1 through A-10 based on the results of the pilot scale inventory. Figures and Tables C-1 through C-7 also identify the infrastructure that needs to be replaced based on capacity. Cost estimates are also included in the tables presented in Appendix C.

Currently, the City of Steamboat Springs performs very little routine maintenance on the stormwater system. Based on interviews with Public Works staff, known problem areas are addressed as needed, and complaints are investigated and addressed if the nature of the problem can be reasonably handled by City personnel. Based on our preliminary assessment, there is the need for one full-time, 2-3 person maintenance crew during the summer storm season (6-8 months of the year). While the specifics of crew size, level of service provided, and equipment are not part of the scope of this master planning study, an average annual maintenance crew cost is estimated to be around $200,000. This level of effort would enable inspections and routine cleaning and re-grading of the system about one time every 5-8 years, depending on the level of service expectations. The maintenance needs identified in this master planning study include cleanout of accumulated sediment from pipes, removal of vegetation, and re-grading to restore swale capacities. Prioritization should be given to the major drainageways identified herein, focusing on lower portions of each basin, and on portions of the system that are upstream of a culvert crossing or component that is not sized for the 100-year storm event or is prone to clogging based on institutional knowledge and experience. As part of the maintenance process, full-scale inventory data should also be collected. Estimated immediate maintenance costs range from $250,000 to $1,000,000.