Draft Report

Little Thompson River Hydrologic Analysis

Prepared for

Colorado Department of Transportation

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CH2MHILL®

9191 S. Jamaica Street
Englewood, CO 80112

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Acronyms and Abbreviations

AMC	Antecedent Moisture Condition
AWA	Applied Weather Associates
CDOT	Colorado Department of Transportation
CDWR	Colorado Division of Water Resources
cfs	cubic feet per second
CN	curve number
CWCB	Colorado Water Conservation Board
FEMA	Federal Emergency Management Agency
FIRM	Flood Insurance Rate Map
FIS	Federal Insurance Study
GIS	geographic information system
HEC-HMS	Hydrologic Engineering Center's Hydrologic Modeling System
I-25	Interstate 25
LiDAR	Light Detection and Ranging
LULC	Land Use and Land Cover
NED	National Elevation Dataset
NOAA	National Oceanic and Atmospheric Administration
NRCS	Natural Resources Conservation Service
SCS	Soil Conservation Service
SPAS	Storm Precipitation Analysis System
US 36	U.S. Route 36
USACE	U.S. Army Corps of Engineers
USDA	U.S. Department of Agriculture
USGS	U.S. Geological Survey

This Document Prepared by:

Management Review

Cory Hooper
CH2M HILL
Water Resources Engineer

Doug Stewart
CH2M HILL
Transportation Technologist Professional

Tim Eversoll
CH2M HILL
Manager – Transportation Engineer

Preparation Team

Morgan Lynch
CH2M HILL
Water Resources Engineer

James Woidt
CH2M HILL
Water Resources Engineer

Christina McDonough
CH2M HILL
Water Resources Engineer

Technical Support

Brad Bettag
CH2M HILL
Water Resources Engineer

Luke Heyerdahl
CH2M HILL
Water Information Management Specialist

John Hunt
Ayres Associates
Manager – Senior Hydraulic Engineer

Executive Summary

In September 2013, the Colorado Front Range experienced an extensive rainstorm event spanning approximately ten days from September 9th to September 18th. The event generated widespread flooding as the long duration storm saturated soils and increased runoff potential. Flooding resulted in substantial erosion, bank widening, and realigning of stream channels; transport of mud, rock and debris; failures of dams; landslides; damage to roads, bridges, utilities, and other public infrastructures; and flood impacts to many residential and commercial structures. Ten fatalities were attributed to the floods.

During and immediately following the rainstorm event, the Colorado Department of Transportation (CDOT) engaged in a massive flood response effort to protect the traveling public, rebuild damaged roadways and bridges to get critical travel corridors open again, and engage in assessments and analyses to guide longer term rebuilding efforts. As part of this effort, CDOT partnered with the Colorado Water Conservation Board (CWCB) to initiate hydrologic analyses in several key river systems impacted by the floods. The work was contracted to three consultant teams led by the following firms:

Boulder Creek, Little Thompson River	CH2M HILL
Big Thompson River, St. Vrain Creek, Lefthand Creek	Jacobs
Coal Creek, South Platte River	URS

The purpose of the analyses is to ascertain the approximate magnitude of the September flood event in key locations throughout the watershed and to prepare estimates of peak discharge that can serve to guide the design of permanent roadway and other infrastructure improvements along the impacted streams. These estimates of peak discharges for various return periods will be shared with local floodplain administrators for their consideration in revising or updating any current regulatory discharges.

The primary tasks of the hydrologic analyses include:

1. Estimate peak discharges that were believed to have occurred during the flood event at key locations along the study streams. Summarize these discharges along with estimates provided by others in comparison to existing regulatory discharges. Document the approximate return period associated with the September flood event based on current regulatory discharges.
2. Prepare rainfall-runoff models of the study watersheds, input available rainfall data representing the September rainstorm, and calibrate results to provide correlation to estimated peak discharges.
3. Prepare updated flood frequency analyses using available gage data and incorporate the estimated peak discharges from the September event.
4. Use rainfall-runoff models to estimate predictive peak discharges for a number of return periods based on rainfall information published by the National Oceanic and Atmospheric Administration (NOAA) [NOAA Atlas 14, Volume 8, Updated 2013]. Compare results to updated flood frequency analyses and unit discharge information and calibrate as appropriate.

This report documents the hydrologic evaluation for the Little Thompson River. As part of the evaluation, CH2M HILL developed a rainfall-runoff model to transform the recorded rainfall to stream discharge using the U.S. Army Corps of Engineers' (USACE's) HEC-HMS hydrologic model. The hydrologic model was calibrated through adjustment of model input values that represent land cover and soil conditions. The calibration of these parameters is common because they take into account vegetative cover, soil structure, topography, land use history, and other considerations that are not easily accessible using aerial imagery. In addition to closely evaluating land use cover, research was completed to determine how the water supply dams at Big Elk Meadows impacted flooding at US 36 during the September 2013 storm event. It was concluded that the Big Elk Meadow Dams were intended only for water supply and a series of the dams *failed* during the flooding event. These dams are currently being evaluated by the State Engineer's Office. Typically, water supply dams are not modeled when evaluating peak discharge rates; therefore, these dams and waters supply reservoirs were not included in the hydrologic modeling efforts. A comparison of observed discharges and the discharges of the calibrated model are presented in **Table ES-1**.

TABLE ES-1
Little Thompson River Comparison of Modeled Discharges to Observed Discharges

Site Number	HMS Node	Location	Drainage Area (sq miles)	Observed Peak Discharge (cfs)	Modeled Peak Discharge (cfs)	% Difference
#61	LT-J3	Little Thompson River Upstream of Site 59	13.8	2,470	2,258	-9%
#59	LT-J4 Without WF	Little Thompson River Upstream of Big Elk Meadows	17.8	2,680	2,836	6%
#60	LT-J4	Little Thompson River Downstream of Big Elk Meadows	43.19	7,800[a]	8,955	15%
#64	LT-J4 Without LT	West Fork Little Thompson River Upstream of Little Thompson River	25.4	6,200	6,221	0%

[a] – This site was inaccessible and the observed peak discharge was estimated based on observations along similar, adjacent watersheds.
cfs = cubic feet per second

The calibrated model was then modified to estimate the 10, 4, 2, 1, and 0.2 percent annual chance peak discharges (10-, 25-, 50-, 100-, and 500-year storm event) based on a 24-hour Soil Conservation Service (SCS) Type II Storm and recently released 2014 National Oceanic and Atmospheric Administration (NOAA) Atlas 14 rainfall values (NOAA, 2014). The modeled discharges were then compared to concurrent alternative estimates of annual chance peak discharges. The assumptions and limitations of the various methodologies were closely reviewed, compared, and contrasted. Considering the lack of historical data and previous studies, the predictive model developed as part of the current study is proposed as the appropriate model to revise high-flow hydrology along the Little Thompson River upstream of US 36. These recommended values are shown in **Table ES-2**. With this recommendation, the peak discharges observed along the Little Thompson River during the September 2013 storm event had an estimated recurrence interval that exceeded the 0.2 percent annual chance peak discharge, or a 500 – year storm event.

TABLE ES-2
Little Thompson River Estimate of September 2013 High-Flow Recurrence Interval

		Annual Chance Peak Discharge (cfs)					
Location	Observed Discharge (cfs)	10 Percent	4 Percent	2 Percent	1 Percent	0.2 Percent	Estimated Recurrence Interval (yr)
Little Thompson River Downstream of "Location 103" and Upstream of Site 59	2,470	58	186	376	660	1,777	> 500
Little Thompson River Upstream of Big Elk Meadows	2,680	74	237	477	838	2,254	> 500
Little Thompson River Downstream of Big Elk Meadows	7,800	648	1,365	2,243	3,418	7,504	> 500
West Fork Little Thompson River Upstream of Little Thompson River	6,200	600	1,139	1,769	2,582	5,251	> 500
Little Thompson River at US 36	N/A	651	1,376	2,264	3,455	7,600	N/A

cfs = cubic feet per second