LONG VALLEY CREEK

FLOOD HAZARD MITIGATION PLAN

STOREY COUNTY, NEVADA

MARCH 2024

PREPARED FOR:

STOREY COUNTY PLANNING DEPARTMENT
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1.0 Executive Summary

Flood hazards from Long Valley Creek (LVC) were identified and quantified for the communities of Lockwood Community Corporation and Rainbow Bend based on identification from community members and stakeholders and extensive hydraulic modeling. Bridge crossings on LVC were found to be major sources of flow from the channel into the community in the overbank. The peak flow rate during the 1% annual exceedance probability (AEP) storm, otherwise referred to as the 100-year storm far exceeds the capacity of the existing channel geometry, and feasible expansions of that channel. Flood mitigation alternatives were developed, modeled, and shown to provide a range of reductions in flood risk. These mitigation alternatives were ranked according to likely cost to construct and maintain, the monetary benefit to flood risk reduction, and reduction of flood risk to critical infrastructure in the study area. Table 1-1 below summarizes this evaluation and ranking.

Table 1-1 – Alternatives Ranking

Alternatives Ranking							
Rank	*Alternative*	*Mitigated Flow Rate (cfs)*	*Total Mitigation Project Cost*	*Total Mitigation Project Benefits*	*BCR*	*Structures Removed from Inundation*	*Critical Infrastructure Risk Reduction (1-5)*
1	3	2665	$ 4,333,227	$ 4,868,973	1.12	100	3
2	5	2590	$896,023	$2,138,028	2.38	86	5
3	2	3345	$ 6,502,636	$ 6,319,143	0.97	120	2
4	1	3345	$ 12,782,045	$ 7,071,640	0.55	158	1
5	4	2350	$ 3,024,023	$ 2,486,660	0.82	80	4

Implementation of structural mitigation measures will rely on capital improvements planning, grant identification, refinement in design, permitting strategy, and grant management. Recommendations and expected sequencing for implementation are provided.

Structural mitigations alone will not eliminate flood risk, and general recommendations for non-structural mitigation measures are provided.

2.0 Introduction, Purpose, and Need

Storey County authorized J-U-B Engineers, Inc, (J-U-B) to prepare a flood hazard mitigation plan for Long Valley Creek (LVC). LVC is a tributary of the Truckee River that flows through the communities of the Lockwood Community Corporation (LCC) and Rainbow Bend, referred to collectively in this document as Lockwood. The confluence of LVC and the Truckee River is in Lockwood, approximately four miles downstream from Sparks, NV. Lockwood consists of single-family residences, commercial, and public land uses, and is subject to two primary sources of flooding: the Truckee River and LVC. This plan focuses on LVC as the primary flood hazard source.

The purpose of this plan is to identify flood hazards from LVC in Lockwood, identify mitigation measures for the hazards identified, structural mitigation measures, and provide guidance on implementation of the recommended mitigation measures. Although structural and non-structural mitigation measures are evaluated, the focus of detailed evaluation in this study are the structural mitigation measures. Based on the hydrologic and hydraulic modeling performed to identify flood hazards and mitigation measures, and the preliminary designs and cost estimates in this document, Storey County intends to incorporate the recommended mitigation measures into the Capital Improvements Plan (CIP) for future implementation.

3.0 Flood Risk Evaluation

For this evaluation, flood risk is defined by a coincidence of hazard, exposure, and vulnerability. The flood hazard, or the location, magnitude, and frequency of the flooding, is well-defined as flooding from LVC as a result of major storms of defined annual exceedance probabilities. In this framework, hazard differentiates high or acute danger to life, property, and critical infrastructure from moderate or low dangers. Direct hazard from flooding of the Truckee River is not considered in this evaluation. FEMA provides five categories of flood hazard, characterized by depth times velocity (DV) ranging from low hazard to extreme hazard. This categorization shown in Table 3-1 below was adapted for use in this study.

Table 3-1 – FEMA Flood Hazard Classification

Flood Hazard Severity Classification	Depth * Velocity Range (ft^2/s)
Low	0-2.2
Medium	2.2-5.4
High	5.4-16.1
Very High	16.1-26.9
Extreme	>26.9

Exposure is determined primarily by inundation boundaries of floods and associated flood hazards and describes who and what may be impacted by flooding. Vulnerability, including the presence of critical facilities, is set primarily by demographics and existing development patterns in Lockwood.

Estimation of flood risk was performed primarily using the 1% annual exceedance probability (AEP) flow event, otherwise known as the 100-year flood. Appendix A contains details on the methodology used to estimate the 1% AEP flow. Secondarily, flood risk estimation was performed by considering flood risk during 4% and 10% AEP events, or 25-year and 10-year floods respectively. The flood risks include direct and indirect risks, described below.

Flood risks were identified using the following sources:

- Reporting by residents and the public
- Communication from Canyon General Improvement District (GID) and Storey County Staff
- Hydraulic modeling from this and previous studies
- The Storey County Hazard Mitigation Plan (2020)
- Special Flood Hazard Areas (SFHAs) published by FEMA Flood Insurance Rate Maps (FIRMs) and Flood Information Studies (FIS)

3.1 Summary of Flood Risks in Lockwood

Lockwood is located at the confluence of the Truckee River and LVC, within the floodplains of both. There is little setback between the banks of LVC and nearby residences, roads, and other structures. The contributing watershed is relatively high-gradient and features canyons and few wide floodplains suitable for flood wave attenuation. Within this context, widespread flooding throughout the community for high-magnitude flow rates is expected.

Modeling found that channel capacity is lowest at bridge crossings, and that bridge crossings are the most significant source of channel to overbank flow. In particular, major overbank flow was found to originate from South Canyon Way Bridge and Cercle de la Cerese Bridge.

Nearly every street within Lockwood is subject to at least low-hazard flooding during the 1% AEP event on LVC, aside from hillside streets and roads. Many structures in Lockwood are expected to flood during the 1% AEP event. The extensive flooding is expected to damage existing buildings and require evacuation. The majority of structures in both LCC and Rainbow Bend are expected to flood during the 1% AEP flood (approximately 373 buildings at an inundation depth of 1’ or greater), with a smaller portion of buildings expected to flood during the 4% AEP flood (approximately 166 buildings).

The highest flood hazard is concentrated within the LVC channel. Although the flood mitigation strategy of concentrating flow in a single channel reduces the flood risk elsewhere in Lockwood, infrastructure assets within the channel are at risk of damage or destruction.

Five areas within Lockwood were identified as having particularly high direct flood risk. These areas are characterized by very high or extreme flood hazard flow outside of the LVC channel.

1. Canyon Way from the South Canyon Way Bridge to Cercle de la Cerese (CDC) Bridge
2. Within LCC, proximate to the Storey County Fire Station and north to Peri Ranch Road
3. Avenue De La Argent, Canyon Way from CDC Bridge to Avenue De La Argent, and very small areas of Rue De La Azure
4. CDC from the LVC channel to Rue De La Noir
5. Avenue De La Bleu De Clair from CDC to Rue De La Divoire

In LCC, overbank flow ranges from low to very high hazard, and presents a high risk of injury or death to the population there, especially if directly exposed (as pedestrians). Several streets throughout Rainbow Bend are subject to high, very high, and extreme flood hazard: Canyon Way and Cercle de la Cerese show extreme flood hazard, while Avenue De La Argent and Avenue De La Blue De Clair also exhibit very high hazard flow. This flow intensity presents a risk to pedestrians being swept away or impacted by entrained debris, vehicles sliding or floating and subsequent impacting pedestrians, structures, or other vehicles, and may damage roads. Canyon Way south of Cercle de la Cerese is subject to extreme flood hazard, and since it is a primary evacuation and emergency response route, it is a high flood risk area.

Vulnerable critical infrastructure includes exposed utility crossings at bridges, such as the sewer pipe at the Avenue of the Colors Bridge, shallowly buried utilities elsewhere in the channel, and the many utility poles adjacent to or encroaching into the LVC channel. The wastewater treatment facility on the eastern edge of Rainbow Bend is subject to limited 0-2’ deep flooding.

In addition to the direct flood risks described above, indirect flood impacts are expected, including restricted access to medical care for injuries or conditions unrelated to flood event, sediment and debris accumulation, and periods of economic loss resulting from damage to roads, buildings, and critical infrastructure.

3.2 Direct Flood Risks

Flooding in this category presents direct, acute, short-term risks to life, safety, vehicles, buildings, and critical infrastructure. While the duration of this flooding category is short relative to indirect risks, the resulting damage to critical infrastructure and other structures may result in medium and long-term impacts such as disruptions to utility services and emergency response and recovery efforts. While the magnitude of depth and velocity are higher in the LVC channel, acute risks to life and safety may be higher in these overbank locations because of they are more likely occupied by people.

In this analysis, direct flood risk was determined by evaluating the flood hazard along with vulnerability and exposure, determined mostly by location.

Figure 3-1 below gives an overview of modeled flood hazard in Lockwood according to FEMA’s hazard classification.

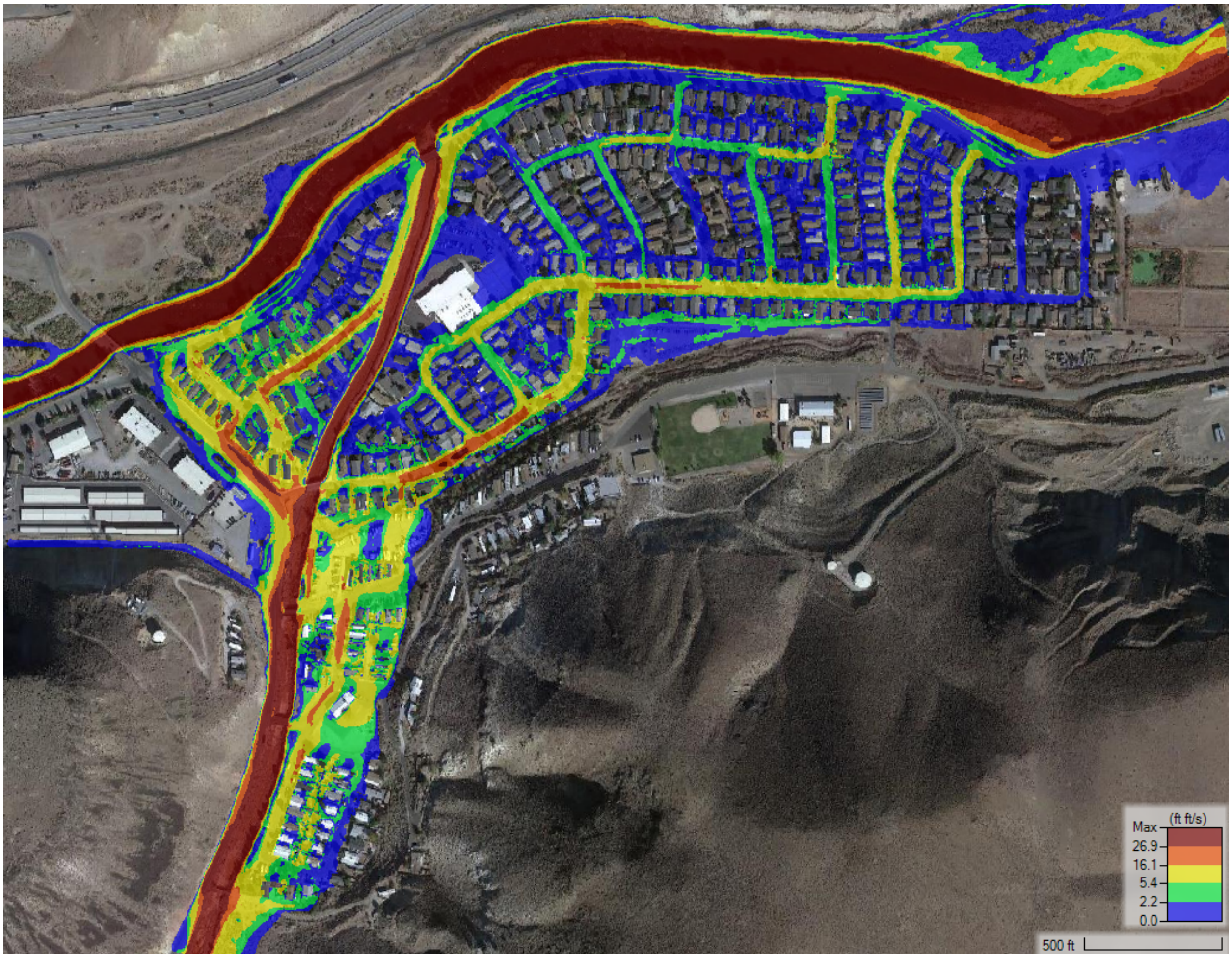

Figure 3-1 – Flood hazard during the 1% AEP flood event in Lockwood, NV.

Low hazard flooding is expected throughout most of LCC and Rainbow Bend during 1% AEP flooding on LVC. This category is comprised mostly of low and moderate hazard severity classes, with some particularly deep, but low-velocity high severity areas. Low hazard flooding presents a low risk to direct, short-term life and safety, but extensive damage to property and transportation systems and potential indirect impacts such as restrictions on emergency access and disruption of utility services. The long duration of low hazard flooding increases its overall impact and related flood risk.

The highest hazard flow is expected within the LVC channel and is very high and extreme hazard flow. While there is likely little exposure to vulnerable populations in this category, the risk to critical infrastructure is relatively high here. The critical transportation infrastructure of the five bridges and the crossings of sewer and water utilities coincident with those bridges may be damaged by high velocity flow and material entrained in that flow. Similarly, bank erosion around electrical and communications infrastructure presents direct and indirect risks to residents and emergency responders.

Debris transportation and accumulation was also identified as a flood risk. Debris increases the risk of injury, death, and damage as flow-entrained objects, and intensifies overbank flooding by decreasing flow capacity within the LVC channel.

3.2.1.1 Assets Vulnerable to Flood Hazards

Sediment deposition within surface and sub-surface stormwater infrastructure is expected during the 1% AEP event. The likelihood and magnitude of deposition is generally expected to be highest closest to the LVC channel and decrease with distance travelled by floodwater. Other assets vulnerable to flood hazards include those found within or near the LVC channel, often in proximity to a roadway crossing. These assets include the following:

- Utility poles and overhead lines near South Canyon Way, North Canyon Way, Peri Ranch Road, Cercle De Cerese Bridges
- At North Canyon Way Bridge,
    - 6" reclaimed water line
- At Peri Ranch Road Bridge,
    - 2" Sanitary sewer force main
    - 6" reclaimed water line
    - 10" water line
- At Cercle de la Cerese Bridge,
    - 6" gas line
    - 8" water line
- At Avenue De La Couleurs Bridge,
    - 8" sanitary sewer
    - 8" water line

Reclaimed water and overhead power poles and lines are identified as potential vulnerable assets depending on their depth of burial. Underground utilities are less exposed but may be vulnerable to high velocity flow. Overhead utilities are vulnerable to undermining of poles and stabilizing wires near or sometimes encroaching in the channel from erosion of channel banks and debris impacts.

The wastewater treatment facility on the eastern edge of Rainbow Bend is subject to limited 0-2' deep flooding. Figure 3-2 below shows the extents of expected low hazard flooding.

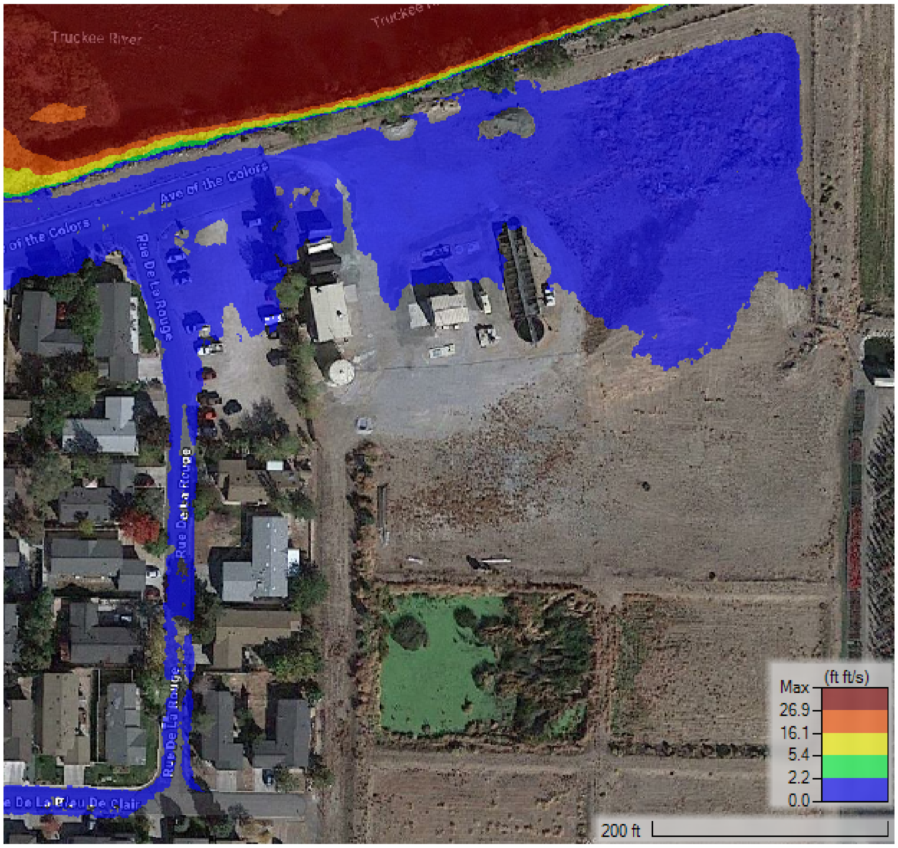

Figure 3-2 – Expected low hazard inundation at the wastewater treatment facility.

3.3 Indirect Flood Risks

Indirect flood risks exclude the acute danger to life and property during the flood event caused by physical impact, inundation, or submergence, and include risks resulting from reduced emergency and non-emergency access, economic impacts from loss of use of buildings, transportation and deposition of debris, sediment, and pollutants, and disruption of utility services.

Residents expressed that access impacts from previous flood events made it difficult or impossible to access medical care unrelated to flooding events. Similarly, disruption in electrical service and/or flood damage rendered individual medical equipment such as oxygen machines inoperable, exacerbating the risk posed by access disruptions. Storey County staff identified flooding on northbound Canyon Way, toward the Interstate 80 (I-80) corridor, as a critical access route that is impacted by flooding. Emergency response and re-building efforts are made significantly more difficult when one or more of the bridges within the Lockwood community are damaged or inaccessible. Alternative access routes are limited, especially during inclement weather, and result in long and uncertain travel times.

Loss of electricity is one of the leading factors in indirect flood risks, and is associated with increased frequency of accidents due to darkness, injury and electrocution related to attempts to restore electricity, carbon monoxide poisoning and asphyxiation from generator operation, and the aforementioned critical medical equipment needs. These risk factors are exacerbated by extreme hot or cold weather.

High velocity flow entrains sediment from upland areas, stream bed, and stream banks during flooding, and deposits sediment in lower velocity areas like the overbank. In Lockwood, deposition and accumulation of sediment can occur in the LVC channel following flood events and is disruptive in the overbank populated areas. Sediment and debris impact access routes, clogs storm drain pipes and inlets, and can enter and damage buildings, vehicles, and machinery. Residents report an increase in sediment volume from upland sources recently.

Similarly, wood, plastic, and metal objects can be entrained from the overbank into the channel, or downstream in the overbank with similar access impacts as sediment. Debris and materials related to the industrial and commercial operations upstream of Lockwood may introduce chemical pollutants into flood waters, making safe access and clean up challenging and time-consuming.

Erosion of footings, debris impacts, and debris accumulation pose a risk to existing utility infrastructure, including electrical, communications, water, sanitary sewer, and storm drainage. Disruptions may present acute dangers as described above, but also may render buildings uninhabitable, and may result in exposure to biological contaminants. Longer term economic impacts and risks include temporary reductions in income from disruptions in residences, access routes, or work places.

3.4 Flood Risks Identified from the Current Flood Information Study

The National Flood Insurance Program (NFIP) defines flooding as a general and temporary condition of partial or complete inundation of two or more acres of normally dry land area or of two or more properties. Relevant flooding sources in Storey County include overflow of inland waters, rapid accumulation, or runoff of surface waters from any source, and mudflow, a river of liquid and flowing mud on the surfaces of normally dry land areas, as when earth is carried by a current of water.

When a major storm develops, water collects rapidly in a short period of time. As a consequence, flows are of the flash-flood type. Flash floods are generally understood to involve a rapid rise in water level, high velocity, and large amounts of debris, which can lead to significant damage that includes the uprooting of trees, undermining of buildings and bridges, and scouring of new channels. The intensity of flash flooding is a function of the intensity and duration of rainfall, steepness of the watershed, stream gradients, watershed vegetation, natural and artificial flood storage areas, and configuration of the streambed and floodplain.

In areas where alluvial fans are present, the flow paths of flash floods lack definition. Flow depths with alluvial fan flooding are generally shallow with damage resulting from inundation, variable flow paths, localized scour, and the deposition of debris.

3.5 Flood Risks Identified by Residents and Community Members

A public meeting was held on March 30, 2023 at the Rainbow Bend Community Center. J-U-B staff presented information on the Flood Hazard Mitigation Plan Project and assisted Storey County staff in soliciting information from the public and answering questions from the public in attendance.

Input gathered from the public in attendance was categorized according to similarities in responses. The following themes were noted:

- General advisories and information
- Reports of channel performance and monitoring efforts
- Flood hazard, exposure, and vulnerability identification
- Project Recommendations
- General and project-specific questions

Within the theme of flood risk identification, participants input included channel capacity limitations, debris and sedimentation, emergency response circumstances and vulnerability, and flood monitoring. The comments have been paraphrased and summarized below.

Channel capacity limitations present flood risk in the form of avulsions or 'break-outs' from the channel into the overbank, containing residences, emergency response facilities, electrical infrastructure, and evacuation routes. Specifically identified locations with low capacity include Canyon Way upstream of Lockwood, the South Canyon Way (SCW) Bridge, the CDC Bridge, and the confluence of LVC and the Truckee River. Non-functional and impaired storm drains were also identified since their impaired condition prolongs the period of inundation. The CDC Bridge was identified as 'the first to be impacted in a flood', while the SCW Bridge was identified as a location needing deepening/dredging to increase capacity and reduce overbank flow.

Commentary on debris and sedimentation as sources of flood risk identified several potential sources of increased sedimentation, including the newly-completed Tahoe Reno Industrial Complex (TRIC) pipeline construction, and focused on the effects of accumulated debris and sediment on channel and bridge opening capacity. Canyon GID staff in attendance confirmed that sediment, debris, and vegetation accumulate and are removed regularly. Previous flooding has also resulting in pressurized propane tanks being washed into and through Lockwood.

The public identified a lack of emergency evacuation routes during flooding of LVC. Additionally, during flood events, power disruption and evacuation routes being blocked result in acute health emergencies for residents who need oxygen, ventilators, etc. Travel within and out of Lockwood may be complicated by the now defunct irrigation canal transmitting flow from the LVC channel to other locations in the communities.

3.6 Flood Risks Identified from Hydraulic Modeling

Hydraulic modeling revealed overbank flood sources and high-risk locations related to high depths and velocities. Modeling showed that flow rates corresponding to the 4% and 1% storms result in extensive inundation of LCC and Rainbow Bend. While the highest risk areas (as defined by the depth times velocity product) are within the LVC channel, many streets contain moderately deep, high velocity floodwater.

Channel to overbank flow was noted at each of the five bridges over LVC in Lockwood. Early flooding to the overbank occurs at SCW and CDC Bridges. Subsequent combinations of backwater effects, overbank flow from other sources, and higher flow rates makes determination of timing of overbank flooding from North Canyon Way (NCW), Peri Ranch Road (PRR), and Avenue de la Couleurs (ADLC) Bridges more challenging and less certain.

Flooding in Lockwood is expected to impact pedestrian and vehicle safety in categories based on FEMA's five flood hazard groupings. A low severity classification is observed as unsafe for small vehicles, and a decrease in hazard for people, while all higher classifications are defined as unsafe for people and vehicles.

3.6.1 Existing Conditions Hydraulic Model

The FEMA flood hazard categories were mapped in the existing conditions hydraulic model to evaluate Lockwood. Higher categories result in difficulty accessing, assisting, and evacuating the area during a flood event. Figure 3-3 shows the existing conditions hydraulic model with the FEMA flood hazard category layer overlaid.

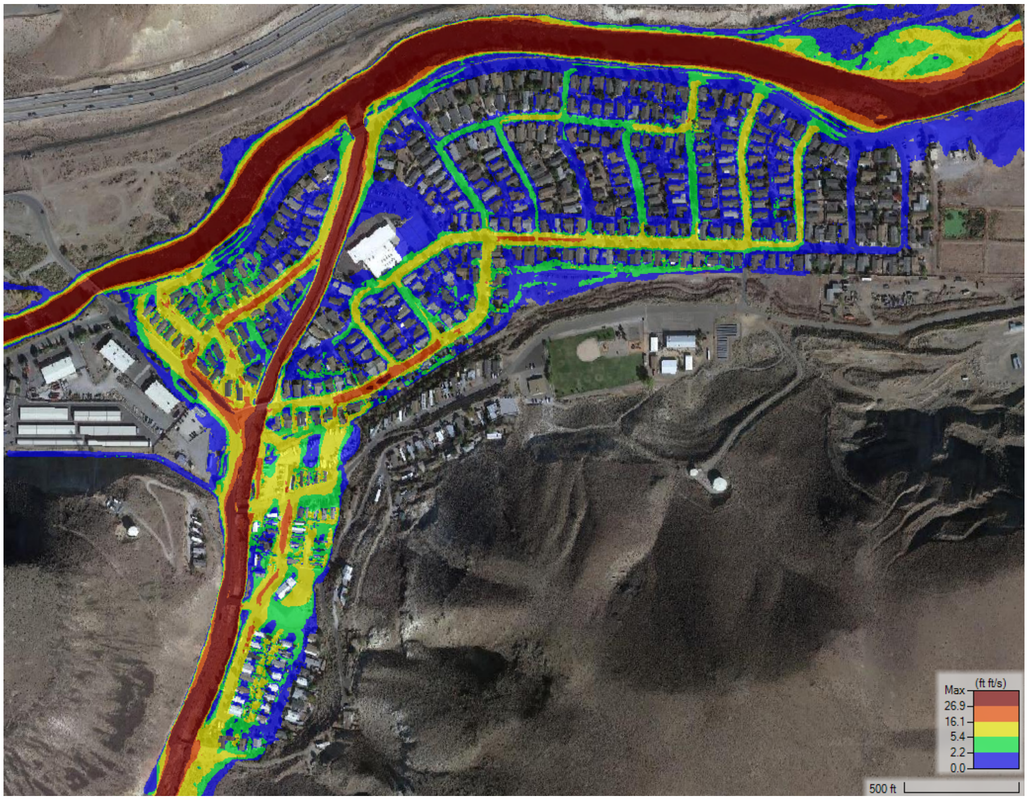

Figure 3-3 – FEMA flood hazard classification of existing conditions hydraulic model results.

Buildings of importance, such as the Sheriff's Office and Fire Station, are crucial to evaluate for accessibility. While both services are needed during emergencies, such as floods, entering and leaving facilities is necessary. The Sheriff's office is accessed via Canyon Way at CDC bridge, in the very-high risk zone. The building itself is surrounded by medium/high risk on the northeast side and low on the southwest side. The Fire Station is in a medium risk zone, surrounded by high-risk zone. Access to and from the Fire Station across bridges must cross medium, high, and very high zones. Structures to North of Fire Station are in high-risk zone. North of the RV storage, where flow path meets CDC, is categorized as a small very high-risk zone. Structures South of the Fire Station are in low, medium, and high-risk zones.

3.6.2 High Direct Flood Risk Areas

Five areas within Lockwood were identified as having particularly high direct flood risk. These areas are characterized by very high or extreme hazard outside of the LVC channel.

1. Canyon Way from the South Canyon Way Bridge to Cercle de la Cerese (CDC) Bridge
2. Within LCC, proximate to the Storey County Fire Station and north to Peri Ranch Road
3. Avenue De La Argent, Canyon Way from CDC Bridge to Avenue De La Argent, and very small areas of Rue De La Azure
4. CDC from the LVC channel to Rue De La Noir

5. Avenue De La Bleu De Clair from CDC to Rue De La Divoire

3.6.2.1 Canyon Way

This area is adjacent to the LVC channel and is subject to the most severe out-of-channel flood hazard flow. This area contains an emergency access route and flooding here exposes those attempting to evacuate or provide emergency services on Canyon Way to high, very high, and extreme hazard flows. Figure 3-4 below shows the DV hazard categorized according to FEMA methodology overlaid on satellite imagery of this high-risk area.

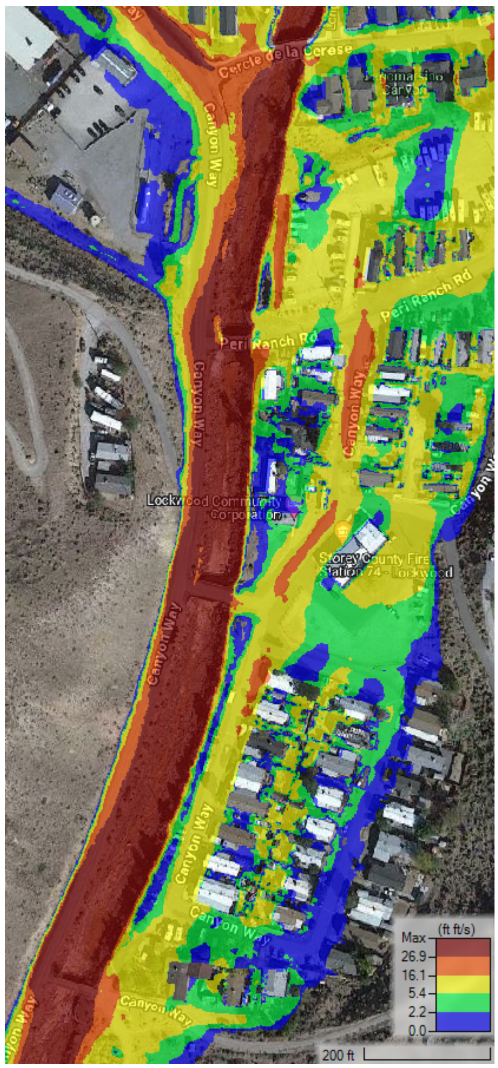

Figure 3-4 – Flood hazards along Canyon Way and within LCC in Lockwood, NV.

The extreme hazard flow covers the entire road surface near South Canyon Way, North Canyon Way, and Peri Ranch Road bridges at the maximum inundation condition. High to extreme hazard flood conditions are present in this location a duration of approximately 8 hours for the first modeled flood wave, and approximately 4.7 hours for the smaller flood wave following the first. During these periods, safe travel on the road would not be possible. The road may be impassible following the first flood wave depending on the damage inflicted on the road and bridge abutments. Based on model results showing flow velocity of greater than 10 ft/s for a duration of approximate 7 hours, portions of Canyon Way near bridge crossings should be expected to be damaged.

This location is also likely to contain flow entrained with debris from upstream sources moving at high velocity in the flow.

3.6.2.2 Lockwood Community Corporation

High hazard flow is present throughout much of LCC, and very high hazard flow is present in several small patches as shown in Figure 3-4 above. The exposure to the public, who may be sheltering in place or attempting to evacuate, make this range of hazards particularly concerning. Portions of high hazard flow are coincident with or in close proximity to residences. These residences, within LCC and on the LCC-Rainbow Bend interface, are likely to be subject to high shear stress, debris impacts, and potentially floatation and sliding depending on how strongly the structures are attached to foundations. Accumulated debris may change flood conditions beyond what was modeled in this effort.

In addition, the proximity of the Storey County Fire Station, with its role in emergency response, further elevates the risk of this area. For the ranges of depths and velocities modeled in this area, direct risks include pedestrians being swept away, pedestrians, vehicles, and structures being impacted by entrained debris, and possible sliding or floatation and subsequent impacts of vehicles. The risk of erosion and undermining of road surfaces is also present and varies depending on the road condition.

Flow conditions classified high or very high hazard persist for approximately 5 hours in this location.

3.6.2.3 Avenue De La Argent and Canyon Way North of CDC Bridge

This location is subject to high, very high, and extreme hazard flow along Canyon Way, with a band of very high hazard flow along most of Avenue De La Argent. While the extreme hazard flow is contained within Canyon Way, high hazard flow and patches of very high hazard flow are present in close proximity to residences on Cour de la Argent. Figure 3-5 below shows the hazard classifications in this location at maximum inundation.

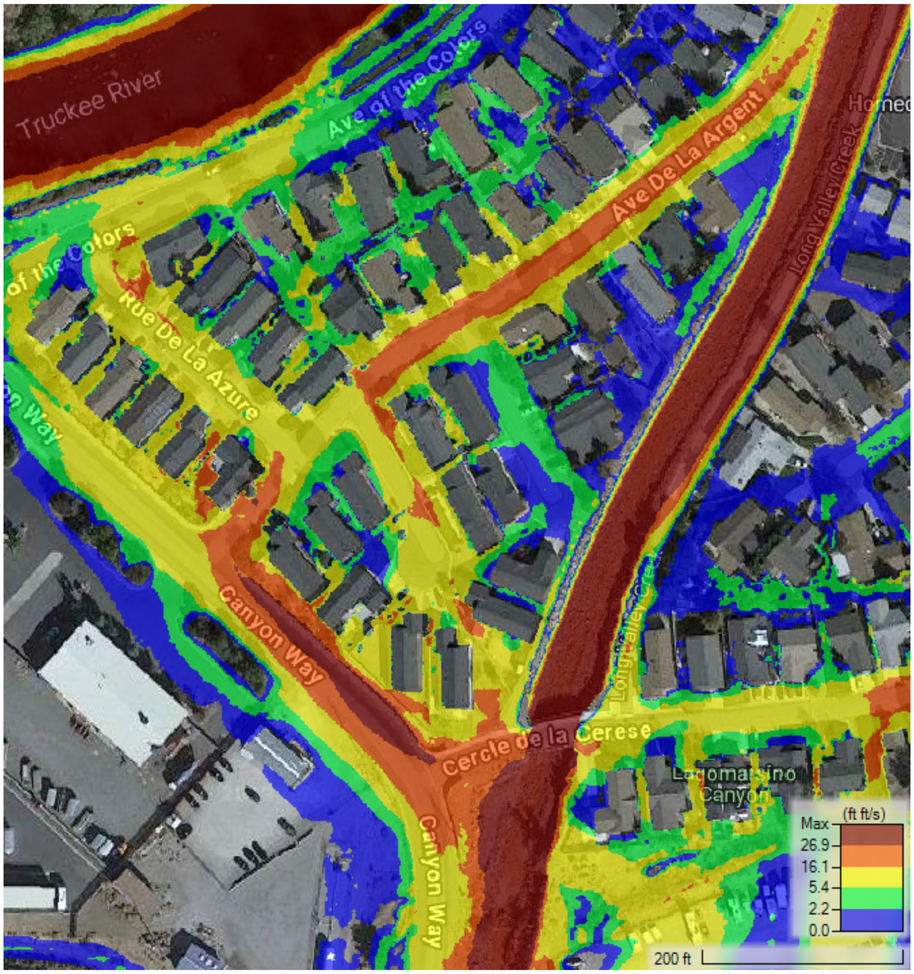

Figure 3-5 – Flood hazards along Canyon Way and Avenue De La Argent.

Risks along this portion of Canyon Way are similar to those in the southern portion of Canyon Way, but with lower areal extent, magnitude, and duration. Residences in this location are likely to be subject to high shear stress, debris impacts, and potentially floatation and sliding depending on how strongly the structures are attached to foundations. Accumulated debris may change flood conditions beyond what was modeled in this effort. Vehicles on Canyon Way and Avenue De La Argent are at risk of floating and sliding, and pedestrians are likely to be swept away. Debris entrained in flow either in the LVC channel or Canyon Way upstream may strike buildings or structures in this location, and may accumulate between buildings, changing flow patterns.

High to extreme hazard flood conditions are present in this location a duration of approximately 7.7 hours for the first modeled flood wave, and approximately 3.7 hours for the smaller flood wave following the first. Hazard intensity is expected to be limited to high hazard during the second flood wave.

3.6.2.4 Cercle de la Cerese

In the 1% AEP flood, Cercle de la Cerese is inundated by floodwater existing the LVC channel at the Cercle de la Cerese Bridge and from floodwater that inundates LCC just upstream. This location is subject to extreme, very high, and high hazard flow, primarily within the road surfaces of Cercle de la Cerese. Figure 3-6 below shows the extents and intensities of flood hazard classification in this location.

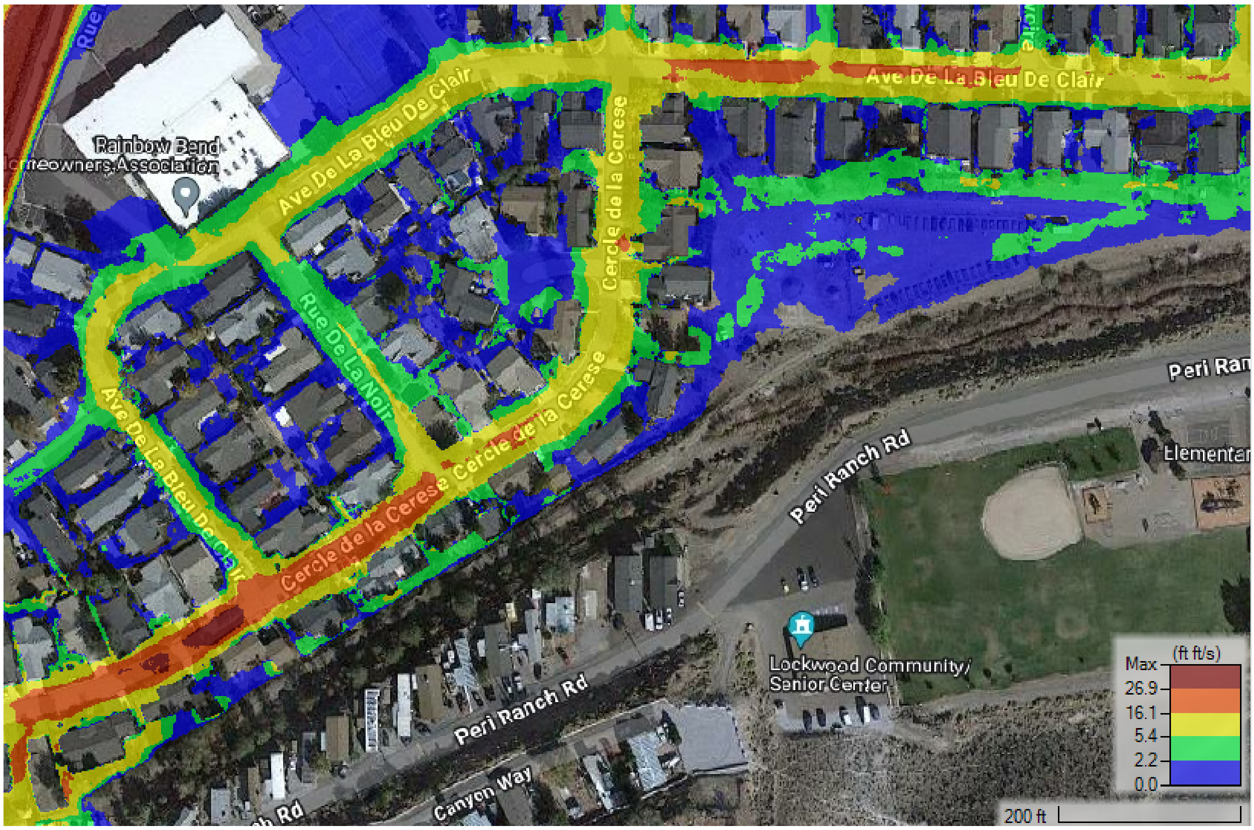

Figure 3-6 – Flood hazards along Cercle de la Cerese and Avenue De La Bleu De Clair.

Within roads, pedestrians will be at risk of being swept away, vehicles are likely to float and slide, and debris impacts are likely. Heavy sediment deposition is expected here following high flow rates, which has clogged local storm drain infrastructure in previous floods.

High to very high hazard flood conditions are present in this location for a duration of approximately 6 hours for the first modeled flood wave.

3.6.2.5 Avenue De La Bleu De Clair

Flow from the overbank at LCC and flow exiting the channel at the Cercle de la Cerese Bridge continues flow along Cercle de la Cerese, and predominantly travels east along Avenue De La Bleu De Clair, and then splits on roads downstream. This location is expected to contain extensive high hazard flow along Avenue De La Bleu De Clair, and Rues De La Jaune, Lavanda, and Mauve, with relatively small portions of very high hazard flow as shown above in Figure 3-6.Figure 3-6 – Flood hazards along Cercle de la Cerese and Avenue De La Bleu De Clair. High hazard flow extends up to driveways and houses along Avenue De La Bleu De Clair, and is less extensive on other roads. Within roads, pedestrians will be at risk of being swept away, vehicles are likely to float and slide, and debris impacts are likely.

High to very high hazard flood conditions are present in this location for a duration of approximately 6 hours for the first modeled flood wave.

3.7 Storey County Hazard Mitigation Plan 2020

Storey County prepared a county-wide Hazard Mitigation Plan in 2020. This plan covers several hazards, including flooding. According to the Storey County Hazard Mitigation Plan, in Storey County flooding is most commonly associated with unusually heavy rainfall and can be influenced by both frontal systems out of the Northern Pacific Ocean and tropical storms coming from the South. Due to the aridity of the County, the area is dry except during and shortly after these storms.

The plan lists the following flood risks:

- Inundation of structures, causing water damage to structural elements and contents.
- Erosion or scouring of stream banks, roadway embankments, foundations, footings for bridge piers, and other features.
- Impact damage to structures, roads, bridges, culverts, and other features from high-velocity flow and from debris carried by floodwaters. Such debris may also accumulate on bridge piers and in culverts, increasing loads on these features or causing overtopping or backwater effects.
- Destruction of crops, erosion of topsoil, and deposition of debris and sediment on croplands.
- Release of sewage and hazardous or toxic materials as wastewater treatment plants are inundated, storage tanks are damaged, and pipelines are severed.

The mitigation plan also lists the affects during flood events and how they disrupt the community. The following are concerns in the community for floods:

- Cause economic losses through closure of businesses and government facilities;
- disrupt communications;
- disrupt the provision of utilities such as water and sewer service;
- result in excessive expenditures for emergency response; and
- disrupt the normal function of a community.

The aftermath of flooding has potentially dangerous affects as well. Cascading impacts identified in the Storey County Hazard Mitigation Plan are as follows:

- Landslides, washouts, and erosion;
- degraded water quality;
- damage to fisheries;
- increase in traffic accidents;
- communications disruptions;
- disruptions to wastewater services; and
- displacement of residents.

3.8 Special Flood Hazard Area and Flood Information Study Model Reviews

Special Flood Hazard Areas (SFHA) are mapped by the Federal Emergency Management Agency (FEMA) and are intended to communicate flood risk, especially for flood insurance determinations. SFHAs are categorized according to expected inundation depth, method of determination, and in the case of floodways, intent as a regulatory tool. Effective SFHAs are likely based on one-dimensional hydraulic modeling using approximate topographic mapping.

3.8.1 Special Flood Hazard Area Comparison

J-U-B compared the SFHAs shown in FIRM Panels to 1% AEP existing conditions inundation boundaries resulting from hydraulic modeling performed in this study. Special scrutiny was applied to SFHA Zones AE and AO, which indicate a flood depth of at least 1 foot and carry a requirement for flood insurance. The Shaded Zone X areas were also compared to existing conditions hydraulic model results. Figure 3-7 and Figure 3-8 below show the effective SFHAs and their modeled analogs respectively.

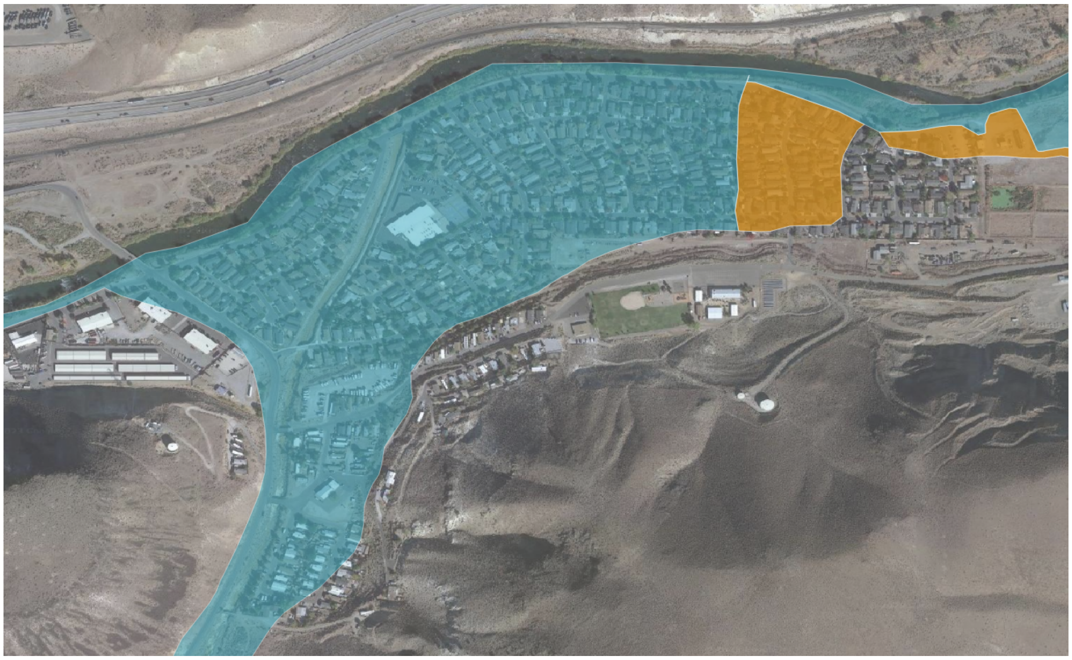

Figure 3-7 – Effective Special Flood Hazard Areas.

BFE-assigned areas (SFHA Zones AE and AO) shown in blue, Zone Shaded X shown in orange.

Figure 3-8 – Modeled Analogs for SFHAs.

Analogs for BFE-assigned areas (SFHA Zones AE and AO) shown in blue, Zone Shaded X shown in orange.

In general, the model results from this study are more detailed than the effective SFHAs. Model results capture details of streets and residential lots more precisely than effective SFHAs. This results in major reductions to areas of building footprints, which were modeled as terrain, and in reductions to areas within residential lots, especially within Rainbow Bend.

In this section, comparisons between effective SFHAs and modeled results will be described as if SFHAs were being updated. Reductions will refer to the modeled inundation boundaries being smaller than the effective SFHAS, and expansions will refer to inundation boundaries being larger in model results than effective SFHAs.

3.8.2 Analysis of Modeled Change in SFHAs Requiring Flood Insurance

Agreement in flood extents were found along nearly all the modeled portion of Canyon Way, the area surrounding the Fire Station, and the RV Storage Lot just northeast of Peri Ranch Road. In Rainbow Bend, the effective SFHAs agree with hydraulic model results within the LVC channel, along with most streets west of Rue De La Jaune. Within LCC, there is major agreement between model results and effective SFHAs. Minor areas of reduction and expansion in inundation boundaries are present along the east side of LCC. More reduction than expansion is expected along the eastern edge of LCC.

Areas of expansion include the street areas east of Rue De La Jaune, a strip of land south of Avenue De La Bleu De Clair, and the commercial and industrial area on the west side of the model domain. In this western portion, the now-unused irrigation channel shows backwatering, and inundation boundaries expand nearer to, but still outside of contact with buildings.

Areas of reduction include large portions of Rainbow Bend and selected areas of LCC.

Figure 3-9 below shows a comparison of the effective SFHAs and their modeled analogs.

Figure 3-9 – Comparison of effective SFHAs for depths of 1′ or greater and their modeled SFHA analogs.

In the figure above, red represents expansions of inundation depths of 1′ or greater outside of effective SFHAs. Green represents areas shown within effective SFHAs, but outside of modeled SFHA analogs. Grey areas represent areas within effective SFHAs and modeled SFHA analogs.

While terrain representations appear much more precise in this study than those used to determine the effective SFHAs, topographic survey may be required to determine whether many residential or other buildings are within SFHAs for the purposes of flood insurance requirement determinations. A reduction or expansion of inundation boundaries close to a building may or may not result in a requirement for flood insurance being removed or added and may or may not result in changes to premium rates. Additional detailed study based on topographic survey is required to make those determinations.

Figure 3-10 below gives a preliminary comparison of building footprints affected by modeled expansions or reductions in SFHA.

Figure 3-10 – Comparison of building footprints preliminarily estimated to be newly within or removed from revised SFHAs.

Additional topographic data and study is needed to revise or verify preliminary estimates. Red represents building footprints affected by expansions of inundation depths of 1′ or greater outside of effective SFHAs. Green represents building footprints shown within effective SFHAs, but outside of modeled SFHA analogs. Grey areas represent building footprints within effective SFHAs and modeled SFHA analogs.

The analyses of SFHAs are based on several assumptions and are subject to limitations. The SFHAs shown in the effective FIRM represent flood risk from the Truckee River and LVC, while the modeled SFHA analogs represent flood risk from LVC almost exclusively. The modeled results are based on LiDAR-derived terrain, and is appropriate for preliminary or feasibility-level study, but must be surveyed in detail prior to official determinations of SFHA changes, requirements for insurance, or insurance rate determinations. The results and comparisons shown here are meant to indicate the differences and similarities in expected preliminary results, not specify revised SFHA boundaries. Determinations of requirement for flood insurance requires further study and structure-specific survey.

4.0 Flood Hazard Mitigation Measures

This study considers flood hazard mitigation measures categorized as structural or non-structural. Structural mitigation measures alter the channel, overbank, or other infrastructure to reduce or relocate flood hazards and the associated flood risks. Examples of structural mitigation measures include upstream storage reservoirs, channel modifications, flood walls, and storm drain improvements. Non-structural measures reduce flood risk by reducing the exposure and vulnerability of a population at risk. In other words, non-structural measures move people away from flood hazards. Examples of non-structural measures include floodproofing like making structures watertight or elevating structures, early warning systems, flood response plans, regulatory requirements for flood risk reduction, and floodplain property acquisition.

The focus of this plan is structural mitigation alternatives. One major constraint applied to the development of structural mitigation measures was that they need not require acquisition or relocation of existing buildings, particularly residences. Storey County continues to collaborate with Lockwood residents to develop a non-structural mitigation plan.

4.1 Flood Hazard Mitigation Measures/Project Identification

Early in the evaluation process, it became clear that the LVC channel capacity was constrained at nearly every bridge, and that bridges were major sources of overbank flow. In addition, the existing channel geometry was found to provide flow capacity well below that of the 1% AEP flood. An additional constraint placed on development of structural mitigation measures was that no existing buildings require relocation or removal, and that residents and businesses be impacted minimally.

Based on these constraints and the flood hazards and risks identified in Section 3, projects were identified for LVC to reduce the impacts of flood events in the surrounding community. Many alternatives were initially considered and preliminarily evaluated. Flood hazard mitigation alternatives preliminarily evaluated include the following:

1. Upstream Storage Reservoirs
2. Flood Walls
3. Debris Basins
4. Bridge Modifications and Removals
5. Channel Modifications
    a. Confluence Modifications
    b. Channel Expansion & Lining
6. Combinations of Channel and Bridge Modifications

Several of these alternatives were preliminarily analyzed and found to have one or more issues disqualifying them from further evaluation in this study. Many others were evaluated using detailed hydraulic modeling and benefit-cost analyses.

4.2 Preliminarily Studied Alternatives

4.2.1 Storage Reservoir

Upstream storage was evaluated as a flood mitigation alternative. Upstream storage has the benefit of providing structural flood hazard mitigation without construction or permanent footprint impacts within Lockwood. Several individual storage reservoirs and a combination of storage reservoirs were preliminarily evaluated to determine feasibility for peak flow attenuation in Lockwood. The objective for flow attenuation in these evaluations were reductions of the peak flow rate in the existing condition down to a peak flow rate within the capacity of existing stormwater conveyance infrastructure.

Simplified hydrograph analyses were performed to estimate reservoir storage required to attenuate the 1% AEP peak flow rate to several target reduced peak flow rates. These analyses assumed that storage reservoirs would have principal spillways, emergency spillways, storage volumes, and operational controls to allow flows equal to or lower than the target flow rate to discharge from the reservoir, while detaining flows higher than the target flow rate. The resulting storage requirements represent minimum required volumes, and would likely require significantly more volume depending on the locations and possible configurations of embankments and outlet works.

Figure 4-1 below shows the required volume to attenuate the 1% AEP flow hydrograph to the target maximum flow rate.

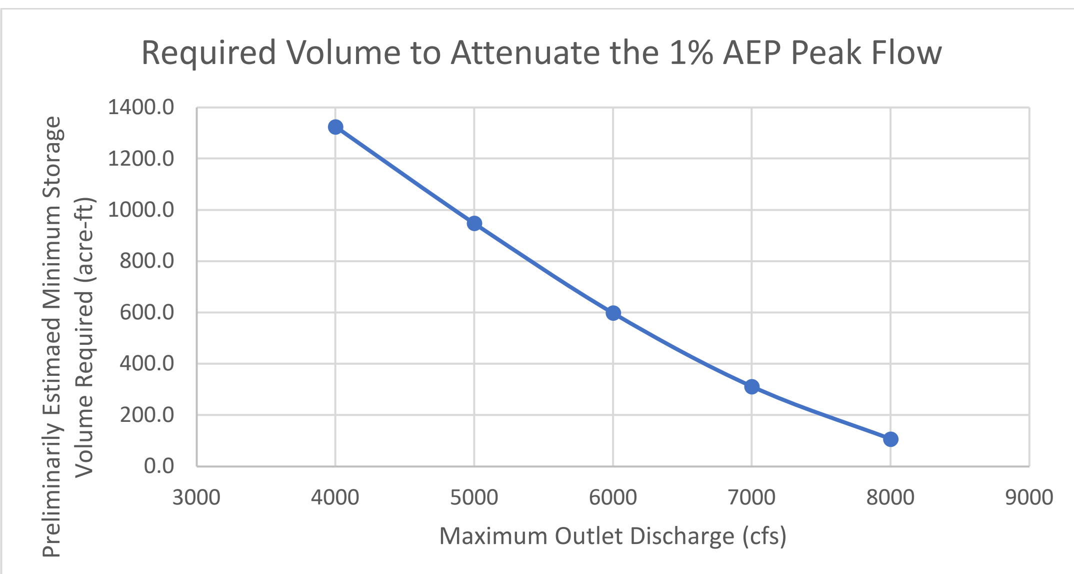

Figure 4-1 – Preliminary estimates of minimum storage volume required to reduce peak flow rates during the 1% AEP flood on LVC.

Several locations within the LVC catchment were preliminarily evaluated for potential stormwater storage. Although the geography of the catchment provides many canyons across which embankments could be constructed, the evaluated locations provided low storage volumes for the required embankment size. Additionally, the apparent feasible storage volume in selected sites was approximately 50-60 acre-ft, which is less than the preliminarily estimated minimum storage volume required for a maximum outlet discharge of 8,000 cfs during the 1% AEP flood. The opportunity to reduce flows during the design storm appears limited using this mitigation alternative.

More detailed analysis would be required to locate suitable potential storage locations, and evaluate each location's storage, required embankment height, and what portion of the watershed contributes to each potential storage location. Two other factors that complicate storage volume mitigation measures are land ownership and site access. Nearly all of the catchment contributing to LVC is owned privately. Existing access infrastructure quality varies significantly in this area, and likely locations of dams impose additional cost for construction of access roads. Acquiring property or permission to build on and inundate property is another challenge to this mitigation measure. Although property owners may be amenable to or welcoming of proposals to work within their property, it is beyond the scope of this study to evaluate that probability.

In summary, the geography of the watershed provides several potential storage locations that may be difficult to acquire underlying land and/or easements for, would have difficult access, would provide relatively small storage volumes for their cost, and depending on their height, might impose additional risk factors on downstream communities. At this time, large scale upstream storage appears infeasible.

4.2.2 Flood Walls

During the public input process, flood walls were advocated for as a flood mitigation measure along LVC to allow a higher contained water surface elevation during flood events. During the same public input process, strong objection to flood walls as flood mitigation measures was also expressed by other individuals.

In the existing hydraulic study for the project area, a limited area suitable for flood walls was identified. To avoid the need to remove existing buildings, excessive wall height, and introducing local cross-channel travel barriers, flood wall evaluation was limited to the portion of LVC along Canyon Way in and adjacent to LCC.

Initial evaluation of flood walls showed that flood walls could contain water along the banks of LVC, the bridge and adjacent road crossings would require temporary water barriers, and would prevent travel over LVC during emergencies. Containing flow within the channel was found to be beneficial locally, directly adjacent to the continuous portion of flood wall, but increased flow was transmitted downstream, where bridges constrained capacity, and overbank flow was intensified. Furthermore, the height of the flood walls would be significantly high to prevent overtopping from the channel. To ensure that the improvement contains floodwaters during the design flood, freeboard was considered for additional wall height.

Local road area constraints, downstream capacity limitations, likely required height, likely cost, and apparent mixed public sentiment made this mitigation measure unsuitable for further consideration in this study.

4.2.3 Debris Basin

A debris basin was considered to decrease the amount of woody debris, sediment, and rocks entering the Lockwood portion of LVC. The basin was preliminarily evaluated directly above SCW Bridge and consisted of a small depression with a concrete flow control structure. The intent of the structure and holding basin would be to concentrate sediment accumulation and debris in a location that does not constrain flow, and increases facility of maintenance. While this mitigation measure may be effective in reducing maintenance costs and hazards related to debris strikes and accumulation, the modeling tools and existing maintenance costs available in this study do not allow for a detailed benefit-cost analysis as other measures do. Additional evaluation of an upstream debris basin was not advanced.

4.3 Alternatives Studied in Detail

4.3.1 Bridge Modifications and Removals

Hydraulic modeling of LVC showed that the bridges over the channel have a significant impact on flooding in the project area. To understand the magnitude of flooding caused by bridge-channel interactions, the project area was evaluated with a series of hydraulic models that explored the impacts of individual bridge expansions & removals, channel expansions, and combinations of bridge expansions and channel expansions. While this process was partially informed by evaluation of existing conditions hydraulic results, it was also highly iterative, with new geometry changes being informed by previous model results.

One of the first scenarios evaluated was one in which all existing bridges over LVC were removed. While this scenario would not be possible due to obvious access issues, it was useful in determining the higher levels of capacity that could be achieved in the channel in the right of way available. Blanket bridge removal was not pursued further, but expansion and modification of bridges in combination with channel modifications were explored in more detail in subsequent alternatives evaluations. Figure 4-2 below shows estimates of the capacity of the channel in the existing condition, and in the hypothetical ‘no bridge’ condition.

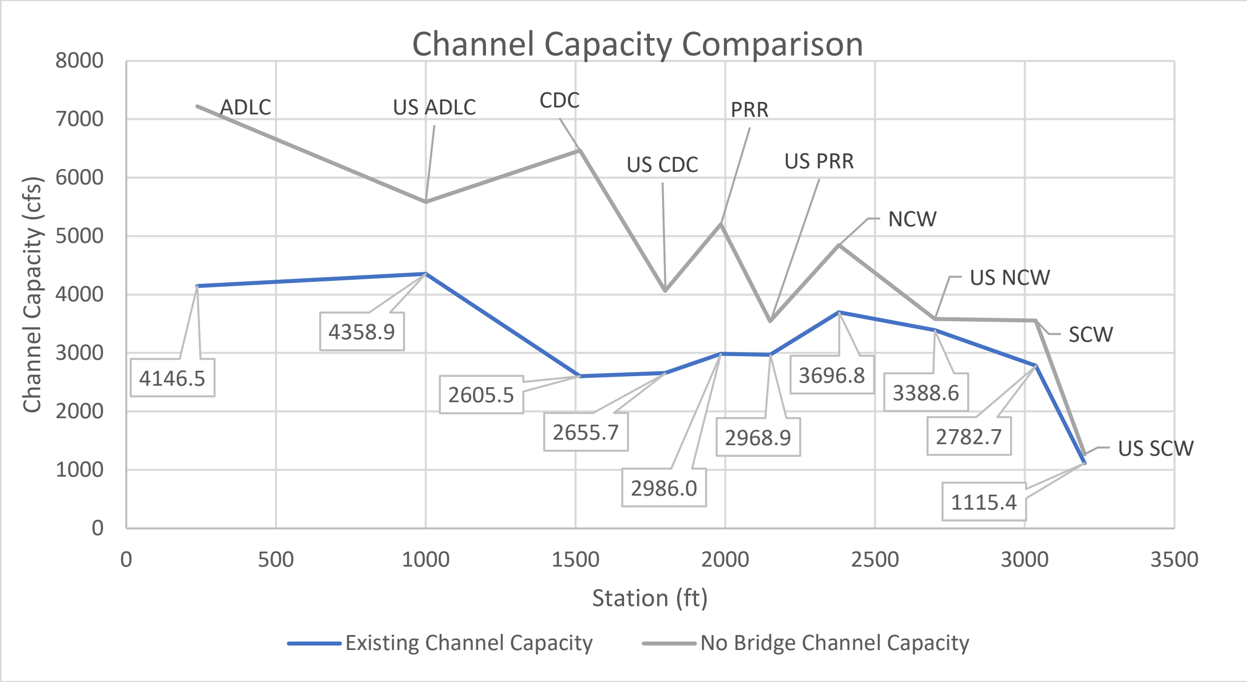

Figure 4-2 – Comparison of existing conditions channel capacity and channel capacity with bridges removed.

This comparison showed the limitations and opportunities of targeted capacity increases and identified capacity bottlenecks in the system, most notably the bridges and channels at CDC and SCW. ADLC and NCW bridges showed a higher and more uniform capacity, while PRR Bridge capacity was intermediate. The largest apparent potential increase in capacity was shown to be at the CDC Bridge, while minimal gains in capacity were expected at channel segments upstream of PRR and NCW Bridges.

Sequential, individual bridge removals were modeled mostly as placeholders for significant bridge opening expansion with the understanding that nearly all bridge crossings would remain in some form. This modeling showed the hydraulic impact of each bridge in the channel system and allowed for improved subsequent alternatives development.

4.3.2 Channel Modifications

Similar to evaluations of bridge modification, multiple channel geometry modifications were evaluated to estimate the maximum flow capacity through LVC within the right of way available. Changes to the channel surface and roughness were also evaluated. The confluence of LVC with the Truckee River at the ADLC Bridge was identified through public input as a location for improvement.

4.3.2.1 Confluence Modification

At ADLC Bridge, LVC flow converges with the Truckee River. The confluence is currently limited in width by the bridge span and the flow moves directly perpendicular to the Truckee River. Two proposed confluence geometry modifications were analyzed. Both proposed geometries oriented the channel outlet further downstream into the Truckee River than the current configuration. While these modifications did not produce significant reductions in water surface elevation throughout the community, limited local reductions in water surface elevation were noted. These improvements were not advanced for further consideration as a stand-alone improvement, but were integrated into other capacity expansion combinations.

4.3.2.2 Channel Expansion and Lining

Two scenarios were developed to determine the response of the entire modeled channel to extensive geometry and roughness changes. Similar to the approach of modeling the LVC system without bridges, these scenarios were meant to estimate the maximum capacity of LVC.

In the first extensive channel expansion scenario, it was assumed that the channel would be composed of concrete, reducing the channel roughness coefficient from 0.035 to 0.013. In addition, the channel bottom was expanded and the channel was made rectangular. Bridge geometries were largely representative of their existing configuration in this scenario. The reduction in roughness throughout the channel was found to have a less than expected effect on hydraulic results, while channel expansion lowered local water surface elevations, but water surface profiles appeared to be influenced very strongly by bridges. Initial benefit-cost analyses showed this scenario to be expensive for its benefit.

The second scenario assumed a riprap lined channel in a trapezoidal configuration, more closely matching the existing configuration, but with an expanded bottom width. Side slopes were limited to a maximum of 2:1, and the channel top was expanded to approach, but not intersect with existing structures. The extensive width required over the length of the channel along with the moderate benefit provided rendered this scenario unviable, as expected.

For each scenario, the modified channel section capacity was estimated, and it was found that even for these relatively high-capacity configurations, there is simply not enough room for a channel to convey the 1% AEP without significant expansion that would negatively impact private property and residential structures.

4.3.3 Targeted Bridge and Channel Modifications

Using the results of the models described above, targeted modifications of selected bridges were designed and evaluated. Bridges at South Canyon Way and Cercle de la Cerese stood out as flow constraining locations, even amongst the other bridges over LVC, and were evaluated first. Using the maximum capacity determinations from the channel expansion, intermediate (less than 1% AEP) were compared with available channel right of way, and a set of five alternatives were developed in more detail. While these alternatives do not totally convey the 1% AEP within the channel, they provide consistent increases in channel capacity by reducing bottleneck effects more uniformly. Preliminary figures showing improvements for each alternative are in Appendix B.

4.3.3.1 South Canyon Way Bridge Removal/Replacement and Channel Expansion (Alternative 5)

Initial backwatering and subsequent inundation of LCC and Canyon Way begins at SCW Bridge, so alternatives for increasing channel capacity at this location were evaluated. The bridge opening is currently constrained by concrete barriers and fill apparently in support of an existing overhead power line. This concrete barrier and fill blocks approximately one quarter of the channel area just upstream of the bridge on the right side of the channel. The left side of the channel is constrained by Canyon Way, with little right of way available for channel expansion to the left. The dimension from the current bridge low chord to the channel bed varies from 4.5 to 6 ft and is one of the smallest bridge openings along LVC. Providing adequate capacity at this location is challenging but could be accomplished a combination of one or more of the following:

- Extensive re-grading to accommodate an elevated bridge,
- Lowering of the channel bed under and adjacent to the existing bridge along with tapering and armoring the slope of the channel upstream to reduce head cutting.
- Removing the existing bridge and expanding existing access ways to residences served by the bridge.
- Expanding the channel cross section.

While the scope of this study did not allow for design and analysis of all of the above options, one combination was selected to preliminarily design and analyze and is representative of the capacity improvement possible in this location, The analyzed configuration of this portion of the channel is removal of SCW bridge and expansion of the channel 40 ft to east for a length of approximately 500 ft. A side slope of 2:1 is proposed, and excavated areas will be lined with riprap to reduce erosion and side slope stability. To maintain access to the residences currently served by the bridge, a preliminary road alignment parallel to the adjusted top of channel is proposed. Road location is expected to vary with final channel configuration. This channel and road reconfiguration is likely to require removal of a portion of fence and several trees in the vicinity of the SCW bridge.

The benefits from this mitigation alternative are mostly local to SCW Bridge and LCC. More floodwater is contained in the LVC channel, and there are localized reductions in depth and velocity, mostly in LCC adjacent to and just downstream of SCW Bridge. Figure 4-3 below shows the change in depth comparing existing conditions to this mitigation alternative.

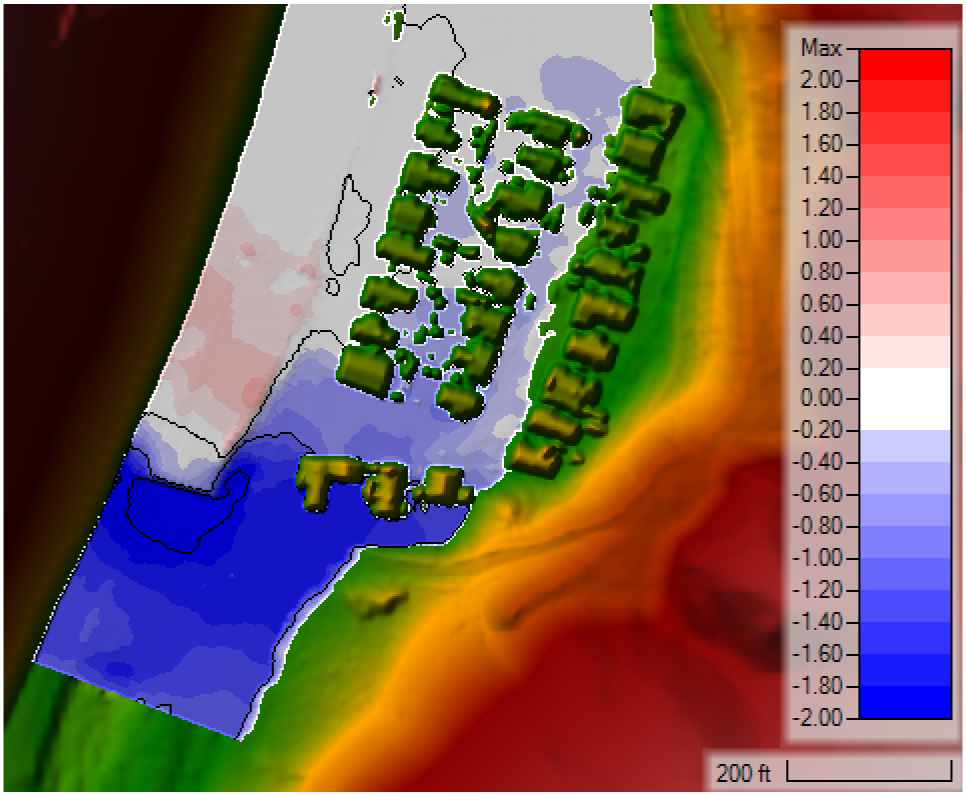

Figure 4-3 – Comparison of peak water surface elevations for this alternative and existing conditions.

Red indicates increases in water surface elevation and blue indicates decreases in water surface elevation as a result of this alternative compared to existing conditions.

As shown in the figure above, water surface reductions as a result of this alternative, shown in blue, are highest directly adjacent to the current location of SCW Bridge. Notable reductions range from 1.2 – 1.8 ft along the upstream edge of residences currently served by the SCW Bridge, and lesser reductions through the portion of LCC just downstream ranging from 0 – 1 ft. Less than 1 in of change results at the fire station.

There is a minor reduction of inundation boundary, mostly limited to LCC vicinity. The most pronounced decrease in inundation boundary outside of LCC occurs at the wastewater treatment plant on the east side of Rainbow Bend.

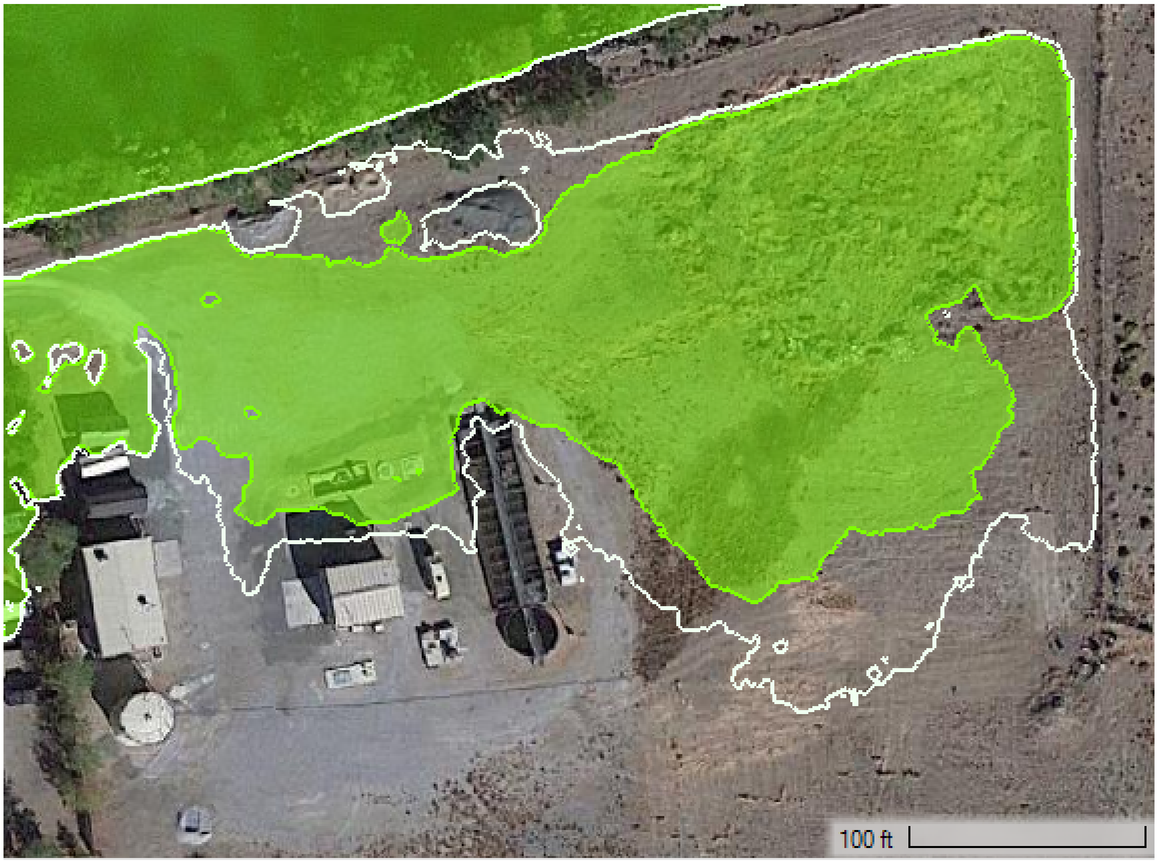

Figure 4-4 – Comparison of inundation boundaries at the wastewater treatment plant. Existing conditions shown in white, this alternative shown in filled green.

This alternative provides a pronounced reduction in DV values adjacent to SCW Bridge, reducing hazard class from high to moderate or low adjacent to six residences. Figure 4-5 below shows a comparison of DV values for this location.

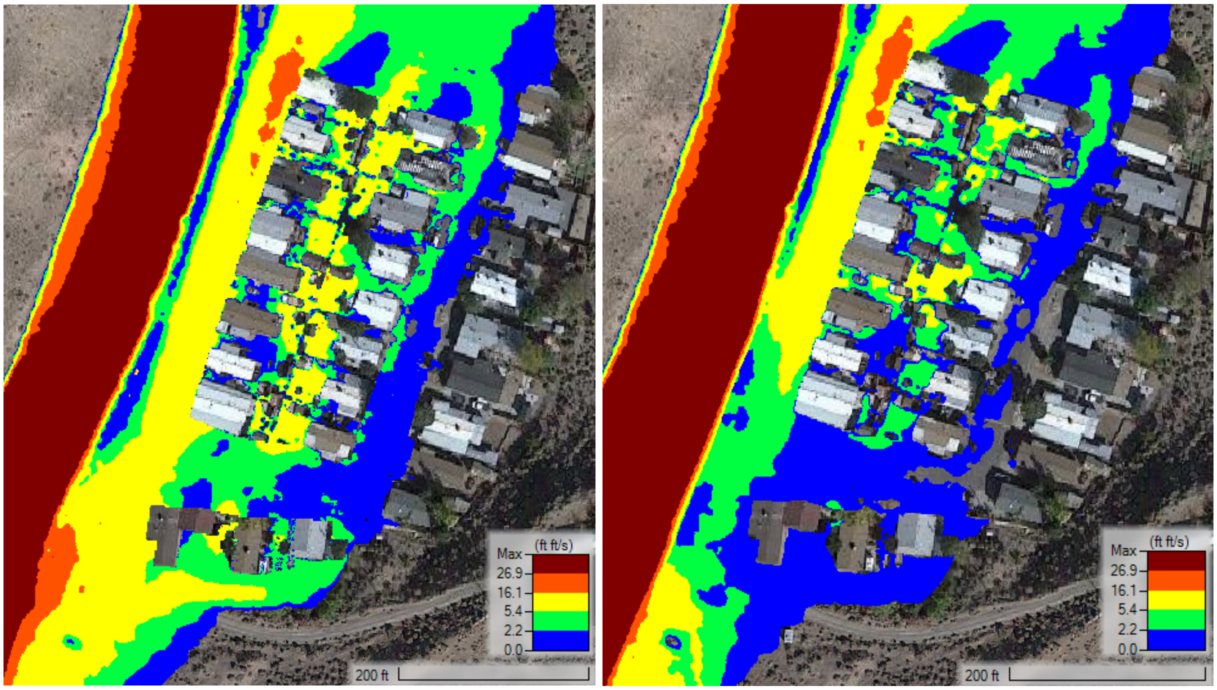

Figure 4-5 – DV values symbolized according to FEMA flood hazard classification. Existing Conditions shown on left, this mitigation alternative shown on right.

4.3.3.2 Cercle de la Cerese Bridge Replacement and Channel Expansion (Alternative 4)

The CDC Bridge was estimated to have the highest potential for capacity increase in the LVC system, as shown in Figure 4-2 above. Even with the capacity improvements from the installation of the bridge following the 2017 flooding, this location was found to have low capacity relative to others along LVC. In addition, the capacity of the channel just downstream of this location is the highest in the LVC system.

In this alternative, the bridge span and channel were expanded approximately 16 ft to the west and 9 ft to the east. This distance was selected to maximize channel capacity without significantly impacting surrounding infrastructure and residential structures. Beneath the bridge, concrete lining and riprap transitions are proposed to reduce erosion of bridge abutments. The proposed average channel depth is approximately 11 ft. **Figure 4-6** shows a cross section of the existing and proposed CDC Bridge improvements.

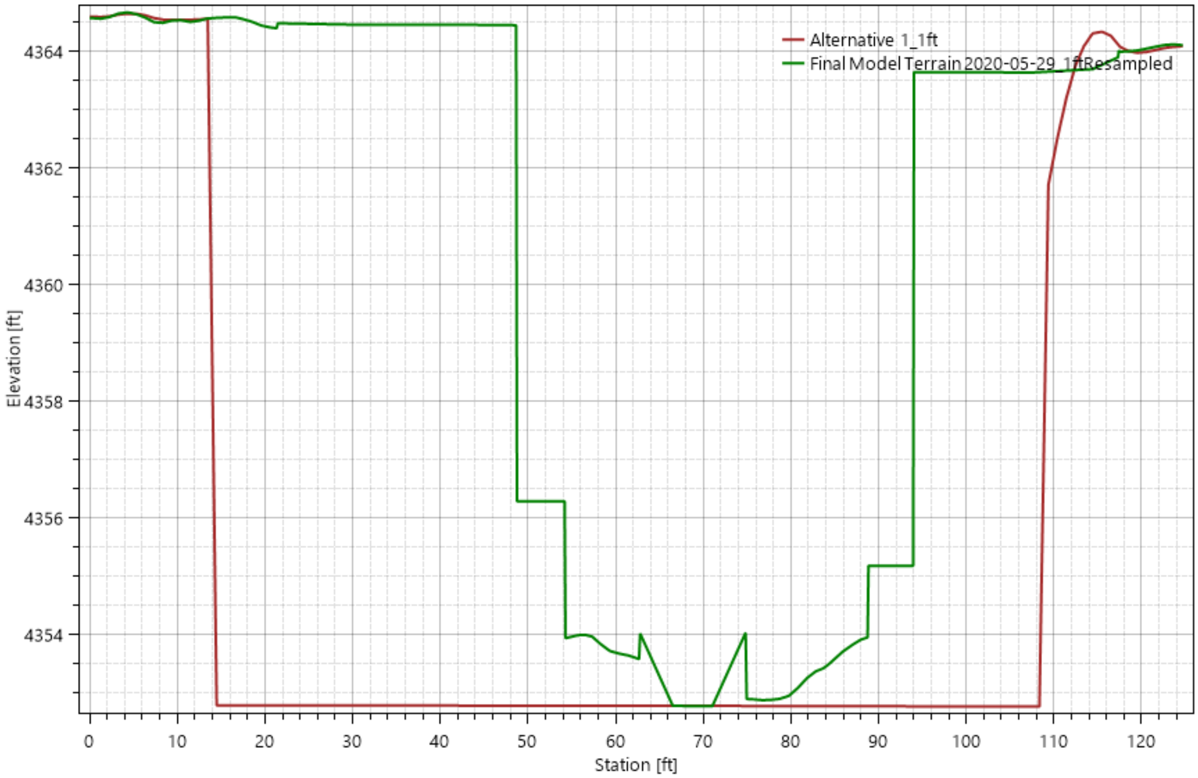

Figure 4-6- Existing (green) and proposed (red) CDC Bridge cross sections.

Similar to the benefits observed for the channel expansion and removal of SCW in 4.3.3.1, the reduction in WSE and apparent flood hazard is mostly local to the area being modified. Figure 4-7 below shows the change in depth comparing existing conditions to this mitigation alternative.

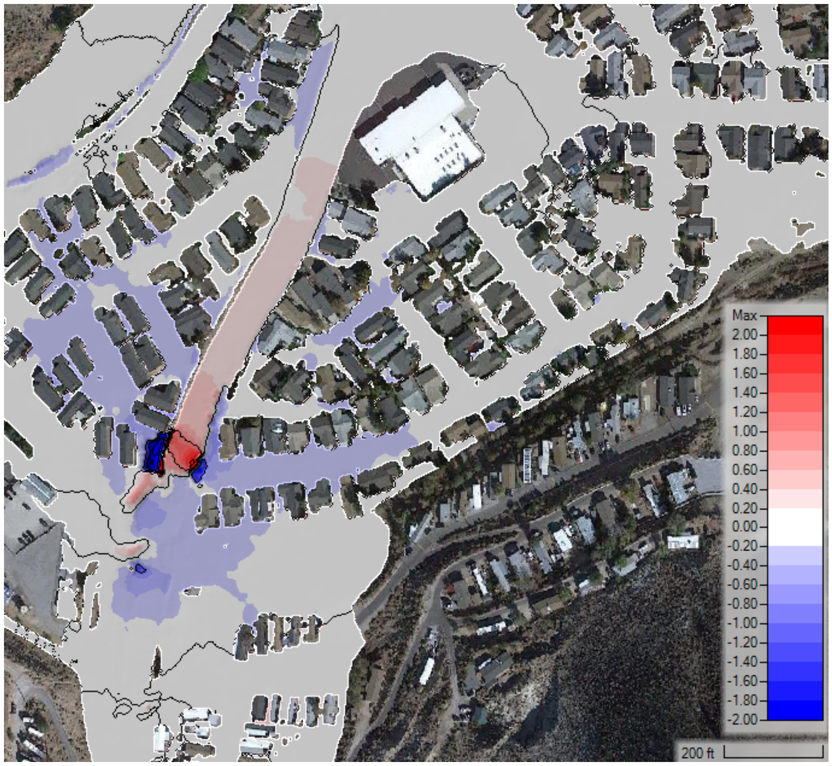

Figure 4-7- Comparison of peak water surface elevations for this alternative and existing conditions.

Red indicates increases in WSE and blue indicates decreases in WSE as a result of this alternative compared to existing conditions.

Moderate decreases in WSE are observed along Cercle de la Cerese to the east and Canyon Way, Cour de la Argent, Cour De La Celedon, and Avenue De La Argent to the west and north. Increases in WSE within the channel shown in red are intentional and desirable up to the channel capacity. Elsewhere in Rainbow Bend and LCC, WSE is largely unchanged. Again, a reduction in inundation boundary is observed at the wastewater treatment facility comparable to that described in 4.3.3.1. Reductions in DV largely correspond in magnitude and extents to the changes in WSE shown above.

In isolation, this mitigation alternative does not result in the hazard reduction and benefits predicted by previous modeling. This is likely due to floodwater having already exited the channel upstream without the opportunity to re-enter the channel upstream of CDC.

4.3.3.3 South Canyon Way Bridge Removal and Channel Expansion and Cercle de la Cerese Bridge Replacement and Channel Expansion (Alternative 3)

In this mitigation alternative, the improvements described in 4.3.3.1 and 4.3.3.2 are proposed jointly.

The observed benefit of this improvement combination is significantly more than those observed for the improvements separately. In Rainbow Bend, the magnitude and extent of hydraulic impacts reduction is higher than either previous alternative. Figure 4-8 below shows the change in depth comparing existing conditions to this mitigation alternative.

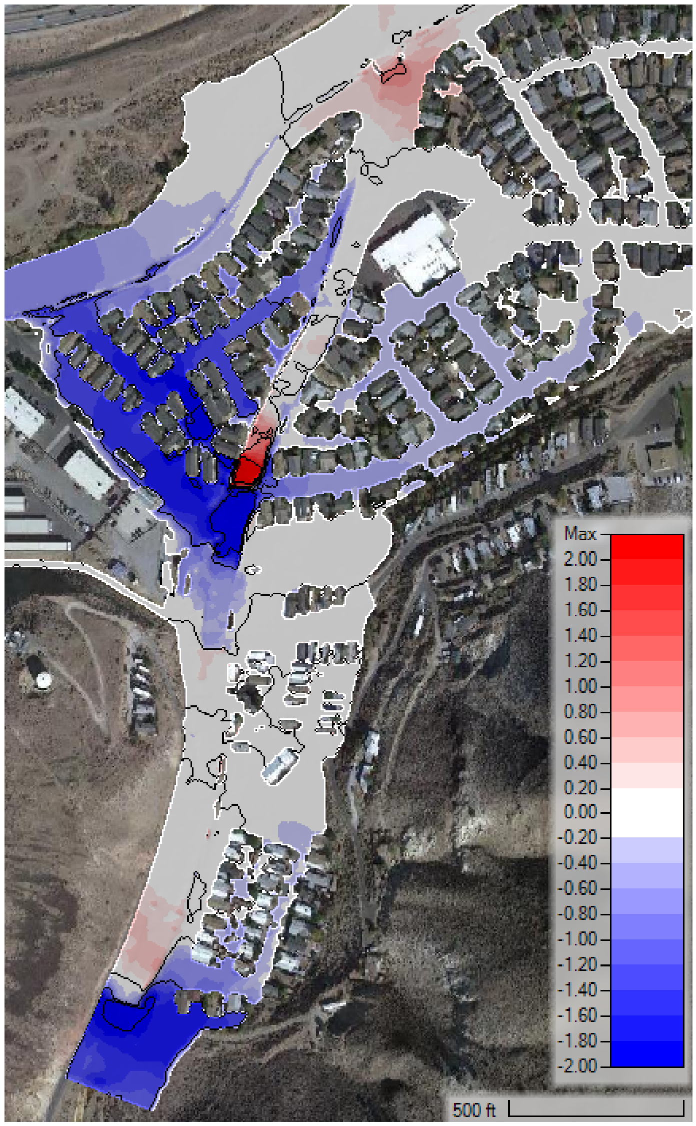

Figure 4-8- Comparison of peak water surface elevations for this alternative and existing conditions.

Red indicates increases in WSE and blue indicates decreases in WSE as a result of this alternative compared to existing conditions.

In LCC, depth reductions are nearly identical those described in 4.3.3.1. Significant WSE reductions are shown along Canyon Way from the CDC Bridge to the Truckee River, along with WSE reductions of similar magnitude on Rue De La Azure, Avenue De La Argent, and Cours de la Argent and Coledon. East of LVC, reductions are more modest, but of a similar extent. At the wastewater treatment plant, the maximum WSE reduction is approximately 1 ft.

WSE increases are observed at the confluence with the Truckee River. Especially within the LVC channel, but also in the adjacent overbank and near several homes, the WSE is elevated as a result of this alternative. The maximum increase in WSE in the overbank in this location is estimated to be approximately 0.9 ft. Figure 4-9 below shows this modeled increase in WSE.

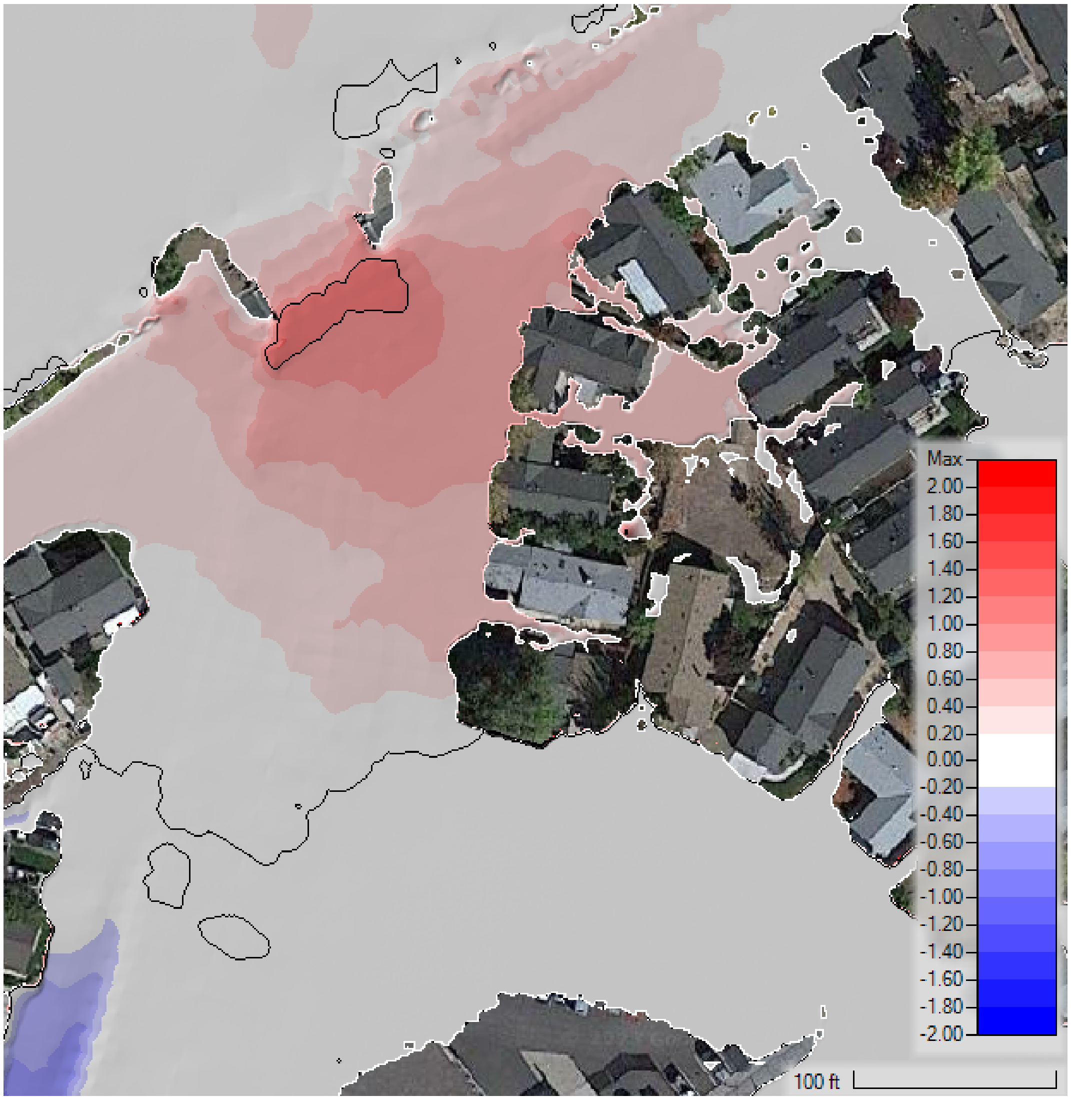

Figure 4-9- Comparison of peak water surface elevations for this alternative and existing conditions at the confluence of LVC and the Truckee River.

Reductions in hazard described by DV are more substantial in this alternative. DV-based hazard class is reduced along Canyon Way and Avenue De La Argent from Very High/Extreme to High hazard only. The extreme hazard area along Cercle de la Cerese and Avendue de la Beau de Clair, but the Very High Hazard area remains.

In LCC, there is reduction to the high hazard area but little change to Very High hazard area adjacent to Fire Station and north of fire station. A reduction in DV is observed along Canyon Way south at the SCW Bridge.

Along with the increase in WSE near ADLC, there is an intensification of DV at ADLC, and an area of Very High Hazard adjacent to LVC channel develops in this scenario. Figure 4-10 and Figure 4-11 below show the modeled DV values in the existing and proposed conditions for this alternative, respectively.

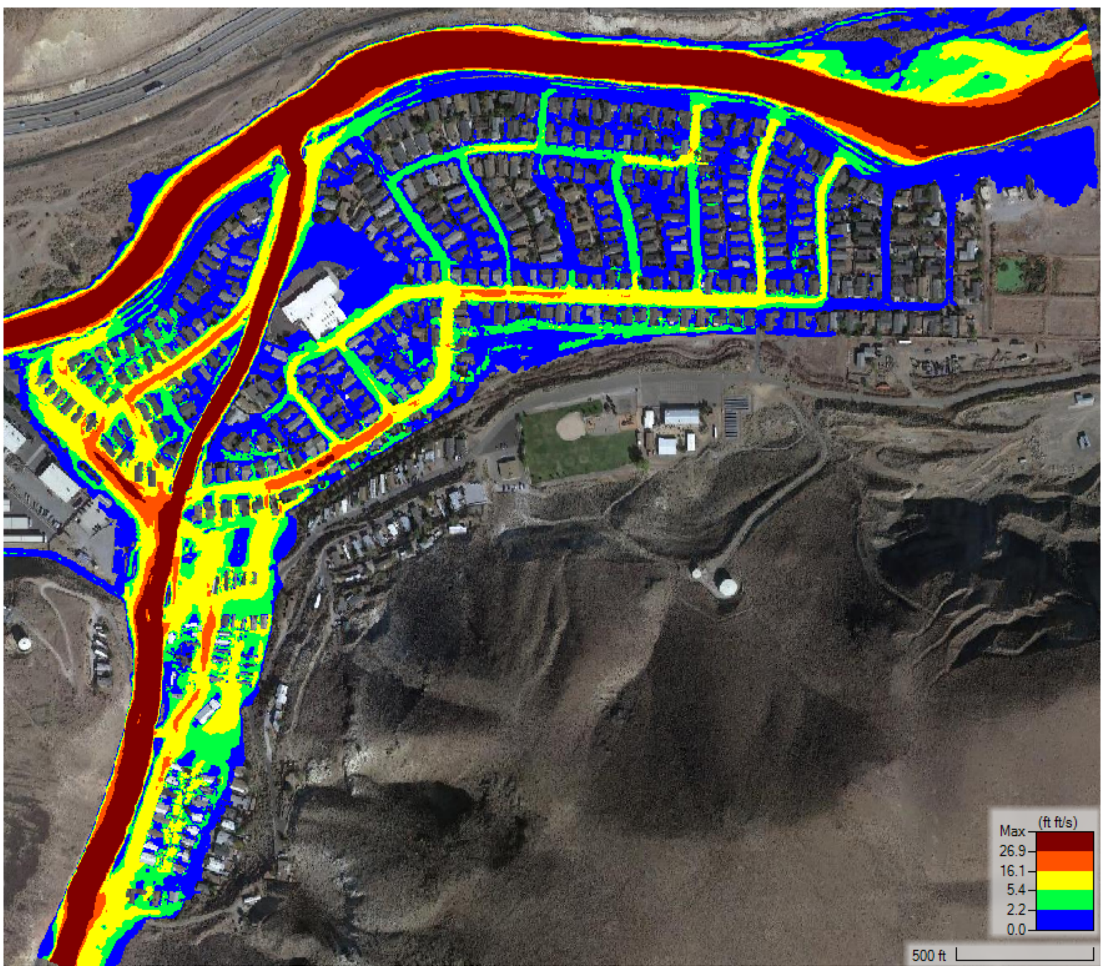

Figure 4-10 – DV values symbolized according to FEMA flood hazard classification for Existing Conditions.

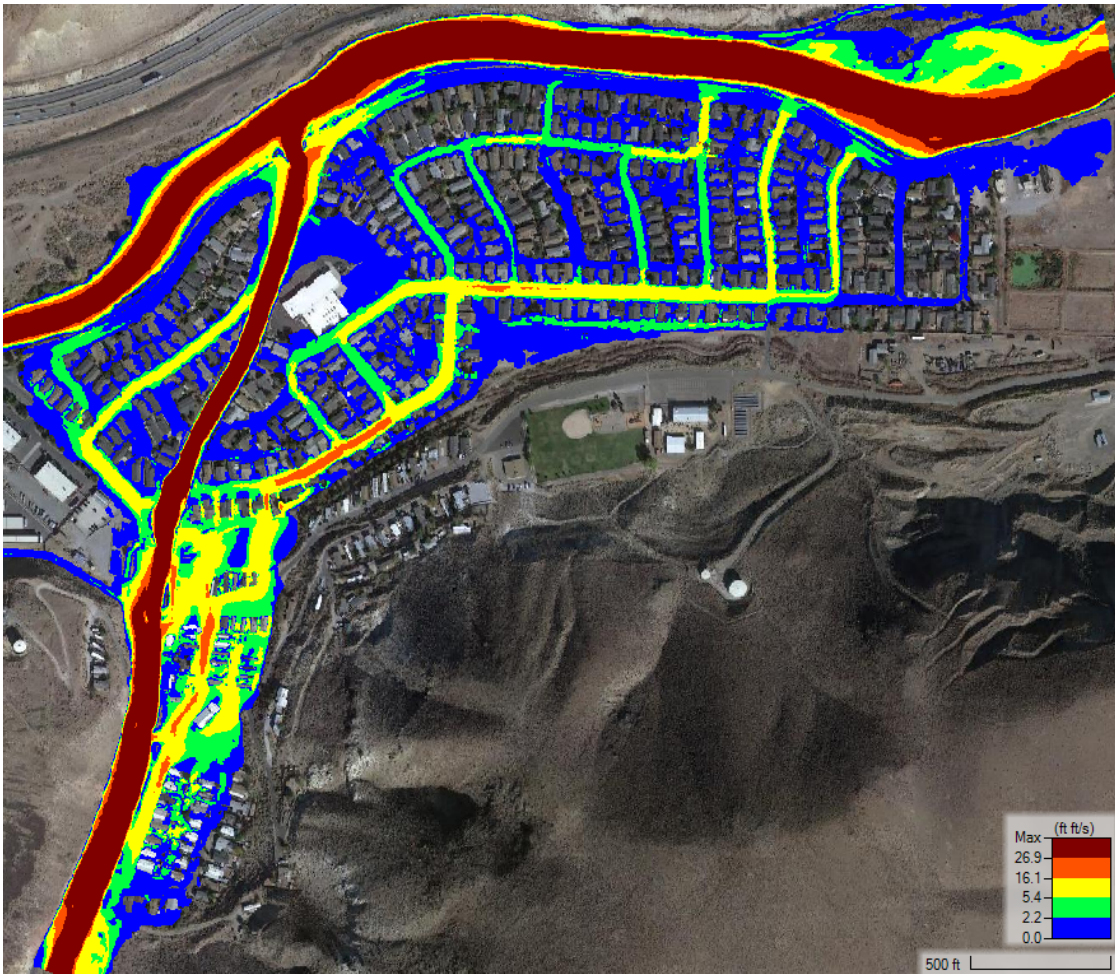

Figure 4-11 – DV values symbolized according to FEMA flood hazard classification for this mitigation alternative.

This alternative yields extensive benefits in the project area by keeping more floodwater in the channel than the existing condition. Flow entering LCC and eventually Rainbow Bend is reduced by increasing the capacity at SCW, and the additional capacity at the CDC Bridge further reduces overbank flow, but the additional flow in the channel exacerbates flooding at the relatively high-capacity ADLC Bridge. Floodproofing, stabilizing, or raising selected structures as a mitigating measure in conjunction with this alternative should be evaluated further.

4.3.3.4 Peri Ranch Road and Cercle de la Cerese Bridges Replacement and Channel Expansions; South Canyon Way Bridge Removal and Channel Expansion (Alternative 2)

In this alternative, the improvements at SCW and CDC described in 4.3.3.3 were supplemented with modifications at PRR Bridge. The PRR Bridge and channel were modified and modeled to provide addition channel capacity. The bridge was relocated north 8 feet to avoid infrastructure and grading conflicts and was extended 18 ft to the west and 2 ft to the east. The channel was widened, concrete lined, and provided riprap transitions upstream and downstream of proposed improvements. The extents of channel expansion are approximately 70 ft long including transitions back to existing geometry.

The resulting reductions in WSE compared to existing conditions are more extensive than previous alternatives described. WSE was reduced compared to existing conditions throughout all of the study area overbank, except for the area adjacent to ADLC. Figure 4-12 below shows the change in depth comparing existing conditions to this mitigation alternative.

Figure 4-12- Comparison of peak water surface elevations for this alternative and existing conditions.

Notable areas of WSE reduction include the fire station in LCC, the Sheriff's Office along Canyon Way, Canyon Way in the vicinity of SCW, PRR, and CDC Bridges, Canyon Way from CDC Bridge to Avenue of the Colors, and the wastewater treatment plant. Increases in WSE were noted at the ADLC Bridge, where the maximum expected increase compared to existing conditions is estimated to be 0.9 ft.

DV-based risk reductions were also observed. From LCC to the CDC Bridge, hazard classification generally decreases in the overbank. Figure 4-13 below shows a comparison of DV values for this location.

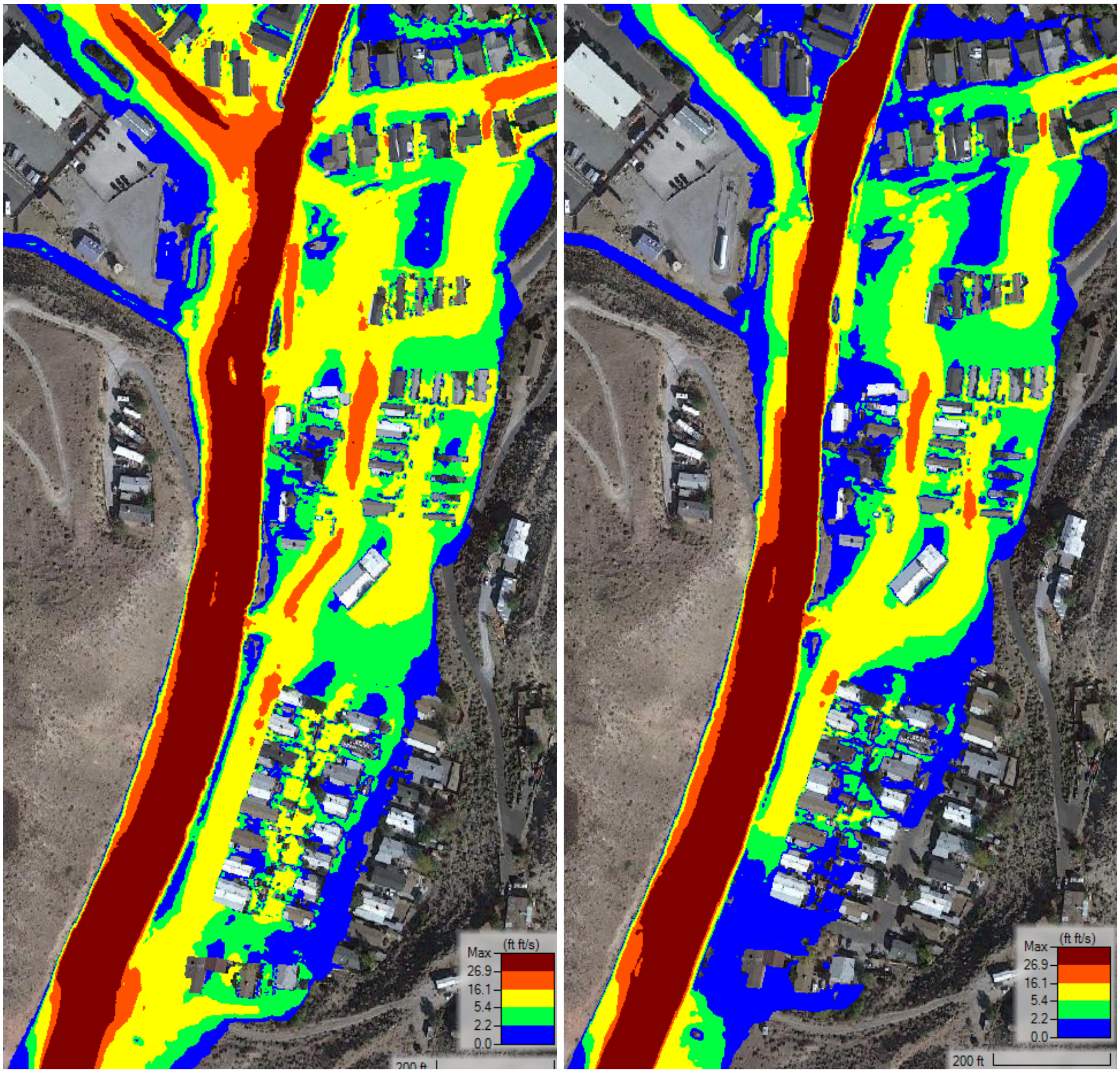

Figure 4-13 – DV values symbolized according to FEMA flood hazard classification. Existing Conditions shown on left, this mitigation alternative shown on right.

Notable changes in hazard classification include extensive reduction of High, Moderate, and Low Hazard areas between SCW and PRR. The flow pattern at the fire station changed such that the Very High Hazard area is reduced, but the High Hazard Area is increased in size. Extreme, Very High, and High Hazard areas along Canyon Way have been significantly reduced.

Inundation boundary reductions are also shown in the figure above, most notably at the Sheriff's Office and the south portion of LCC. Other inundation boundary reductions were observed at the wastewater treatment plant and along Canyon Way toward Interstate 80.

This alternative provides extensive benefits to nearly all the project area but intensifies risk in the area near ADLC with a magnitude and extent like that described in Section 4.3.3.3. Floodproofing, stabilizing, or raising selected structures as a mitigating measure in conjunction with this alternative should be evaluated further.

4.3.3.5 Channel Expansion at All Bridge Locations; South Canyon Way Bridge Removal, Bridge Extension at All Other Bridges (Alternative 1)

In this alternative, the improvements at SCW, CDC, and PRR described in 4.3.3.4 were supplemented with modifications at NCW and ADLC Bridges. At NCW, the channel was extended by an average of 35 feet over a 200 feet length with a 2:1 side slope. The channel beneath the bridge is modeled as concrete lined with riprap transitions upstream and downstream of the concrete lined portion.

This bridge is the primary service bridge for the fire station and must maintain a relatively high weight capacity. The current bridge approach geometry from the west of the bridge is apparently in conflict with vehicles currently using it, as evidenced by damage to the road surface from tail gates and undercarriage elements. Expansion was modeled on the east side of the bridge, and no detailed roadway approach geometry was designed in this effort. A refined expansion dimension will depend on design vehicles and adjacent road surface elevations and will be determined in a future phase.

The bridge at ADLC was extended 22 ft to the west and 50 ft to the east. This asymmetric expansion provided a more efficient discharge angle into the Truckee River, and an expanded channel geometry. The side slopes around the channel are designed as 2:1; however, at the northeast side of the bridge a 10.5 feet concrete wall lines the side for 50 feet. The earthen channel below the bridge was lined with concrete for approximately 350 linear feet and includes riprap transitions to the existing channel bed.

The capacity improvements allow for significantly more floodwater to stay in the LVC and exit to the Truckee River during high flow. However, the estimated 1% AEP peak flow rate exceeds the expanded channel capacity. Therefore, while a portion of the project area sees a reduced inundation boundary, the more substantial and widespread benefits are reductions in overbank depth and velocity.

The benefits observed as a result of improvements in this alternative were the most extensive and highest magnitude of all alternatives modeled. Figure 4-14 below shows the change in WSE comparing existing conditions to this mitigation alternative.

Figure 4-14- Comparison of peak water surface elevations for this alternative and existing conditions.

WSE is reduced throughout the project area overbank, with small increases in WSE limited to within and directly adjacent to the LVC channel. One notable difference compared to the previous alternative is that modifications at ADLC in combination with the other improvements significantly reduce WSE in the vicinity of the bridge. WSE and inundation boundaries are reduced around the Rainbow Bend Community Center, Sheriff's Office, and Fire Station. Nearly every street in LCC and Rainbow Bend are expected to have lower WSE than existing conditions in this alternative.

Similar reductions in DV-based hazard area are noted throughout the project area. Figure 4-15 and Figure 4-16 below show flood hazard classification for existing and proposed conditions respectively.

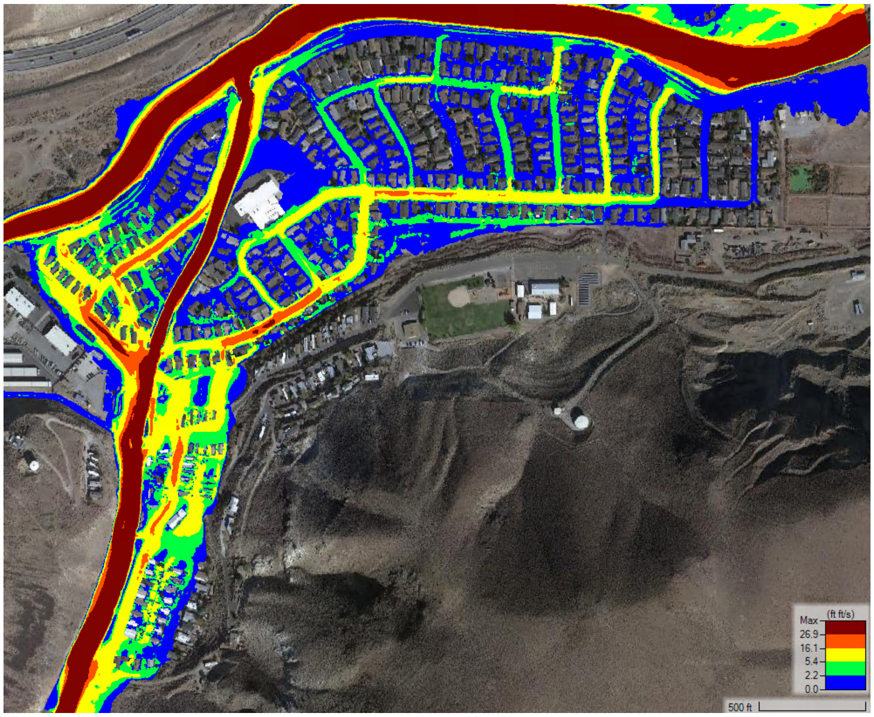

Figure 4-15 – DV values symbolized according to FEMA flood hazard classification for Existing Conditions.

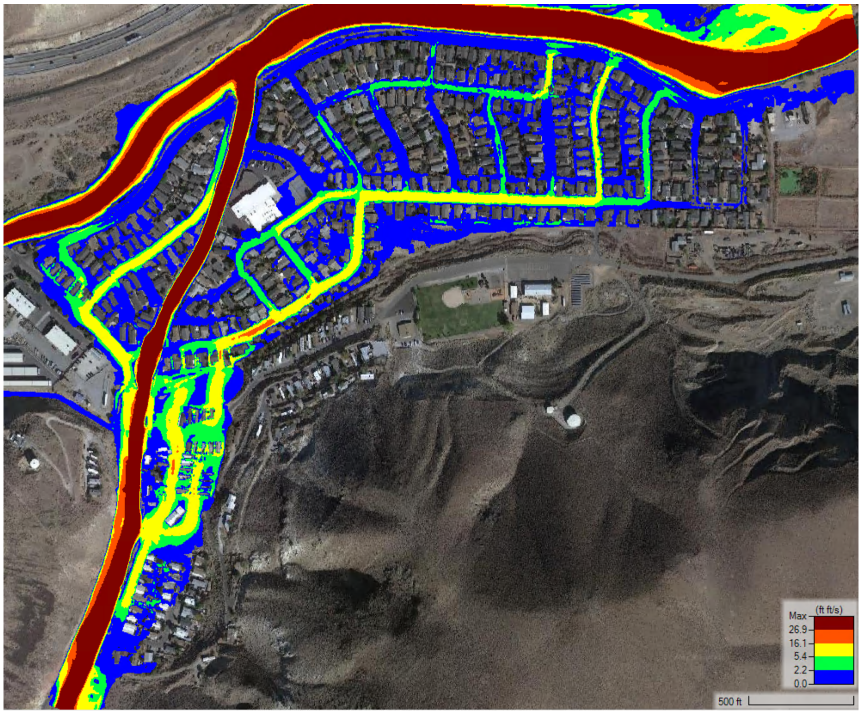

Figure 4-16 – DV values symbolized according to FEMA flood hazard classification for this mitigation alternative.

Very High Hazard areas are eliminated along Avenue De La Beau De Clair, Avenue De La Argent and the surrounding area, and much of Cercle de la Cerese. Many Moderate Hazard areas in the eastern portion of Rainbow Bend have been reduced or eliminated as well.

The hazard areas resulting from improvements in this alternative are very similar to those described in Section 4.3.3.4 along Canyon Way and in LCC. Figure 4-17 below shows a comparison of DV values for this location.

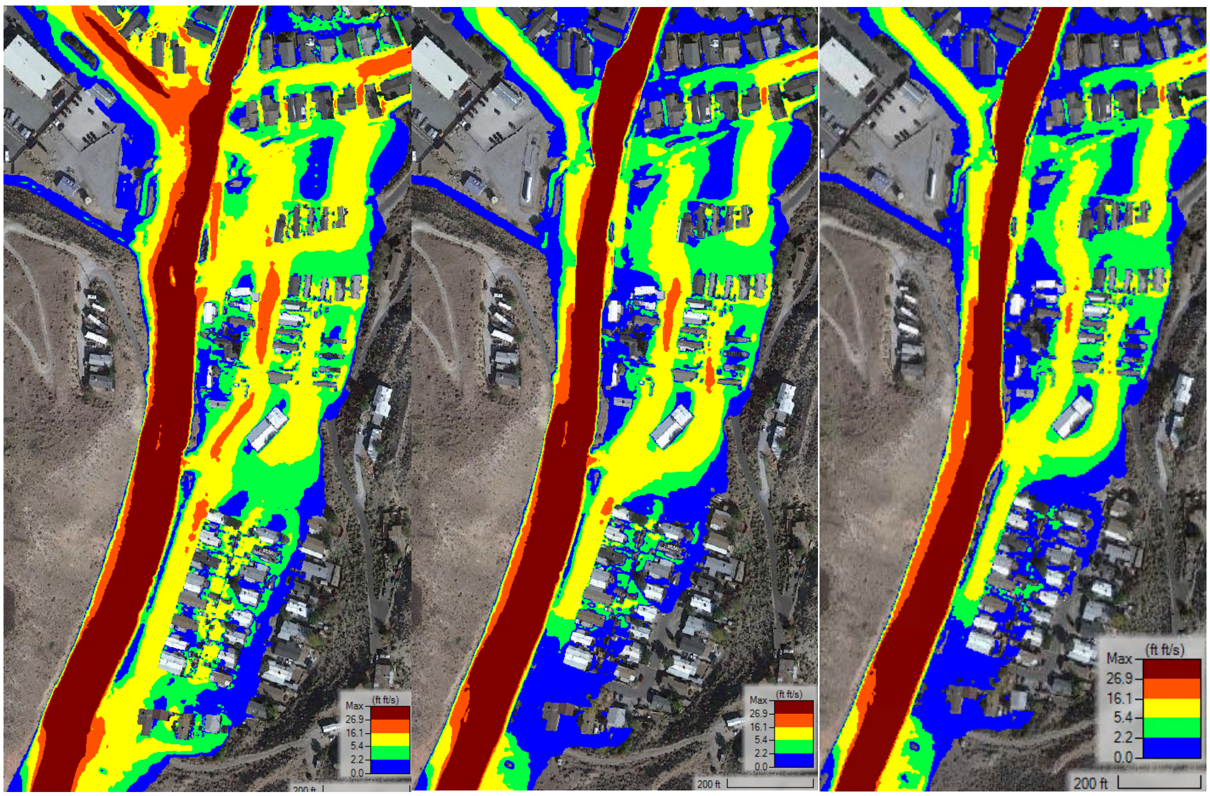

Figure 4-17 – DV values symbolized according to FEMA flood hazard classification. Existing Conditions shown on left, the previous mitigation alternative in center, this mitigation alternative shown on right.

Notable differences between the previous alternative and this alternative include additional reduction of the Extreme Hazard area along Canyon Way in the vicinity of the NCW Bridge, additional minor reductions to Very High, High, Moderate, and Low Hazard areas in LCC. High Hazard areas persist adjacent to the Fire Station, as does a portion of the Extreme Hazard area along Canyon Way between NCW and SCW.

5.0 Ranking and Recommendations

The structural mitigation alternatives described in Section 4.0 above will be referred to in this section as follows:

Alternative 1: Channel Expansion at All Bridge Locations; South Canyon Way Bridge Removal, Bridge Extension at All Other Bridges

Alternative 2: Peri Ranch Road and Cercle de la Cerese Bridges Replacement and Channel Expansions; South Canyon Way Bridge Removal and Channel Expansion

Alternative 3: South Canyon Way Bridge Removal and Channel Expansion and Cercle de la Cerese Bridge Replacement and Channel Expansion

Alternative 4: CDC Bridge Replacement and Extension

Alternative 5: South Canyon Way Bridge Removal and Channel Expansion

5.1 Structural Mitigation Recommendations

The design alternatives are ranked from 1 (most-preferred) to 5 (least-preferred), based on their corresponding target flow rate, mitigation project costs, mitigation project benefits, BCR, structures removed, and critical infrastructure. The ranking and parameters are summarized in Table 5-1below.

Table 5-1 – Alternatives Ranking

Alternatives Ranking							
Rank	*Alternative*	*Mitigated Flow Rate (cfs)*	*Total Mitigation Project Cost*	*Total Mitigation Project Benefits*	*BCR*	*Structures Removed from Inundation*	*Critical Infrastructure Risk Reduction (1-5)*
1	3	2665	$ 4,333,227	$ 4,868,973	1.12	100	3
2	5	2590	$896,023	$2,138,028	2.38	86	5
3	2	3345	$ 6,502,636	$ 6,319,143	0.97	120	2
4	1	3345	$ 12,782,045	$ 7,071,640	0.55	158	1
5	4	2350	$ 3,024,023	$ 2,486,660	0.82	80	4

J-U-B recommends further developing the designs and analyses, then implementing these alternatives as funds allow.

5.1.1 Ranking Parameters

The mitigated flow rates are estimated from the modeled capacity of the channel in HEC-RAS. These flow rates are approximately equal to the 10% AEP (10-year) flood event peak flow rate.

5.1.2 Benefit-Cost Analysis

5.1.2.1 Opinion of Probable Cost

The three recommended flood hazard mitigation projects were quantified and evaluated for an opinion of probable cost (OPC). The preliminary estimate of the project's costs was based on past data and project information. The three alternatives were quantified for materials, cost of labor, and equipment. Appendix C shows details and assumptions regarding bridge removal and replacement, channel excavation and lining, and utility improvements. Appendix B shows preliminary figures of improvements.

5.1.2.2 Preliminary FEMA Benefit-Cost Analysis

To be eligible for the FEMA Hazard Mitigation Assistance (HMA) funding it is required that applicants utilize the FEMA Benefit Cost Analysis (BCA) tool. This tool helps develop the Benefit Cost Ratio (BCR) and aids in determination of which channel design, corresponding to the 10%, 4%, and 1% AEP (10-, 25- or 100-year) flood events, provides the greatest benefit and the least cost. Essentially, the highest BCR is used to present the maximum benefit to cost ratio. For a viable project to be determined, FEMA requires a BCR greater than one.

Baseline assumptions were made while completing the BCA tool. The structure types were simplified to single-story residential homes without a basement which specifically excludes the schools and commercial areas. This structure type represents most of the structures existing in the inundation boundary. Assumptions were also made for the residential building year. As the Rainbow Bend community is larger than the Lockwood Community Cooperation, Rainbow Bend was used as the built year assumption. The Rainbow Bend residential community was built between 1987-2006 so the average year of 1997 was utilized in the BCA tool. The total square footage of houses in Lockwood were individually calculated by adding the residential and garage square footage, which were estimated using GIS tools. Lastly, the finished floor elevations (FFE) used for the pre- and post-mitigation calculations were replaced by the depth raster values, as the FFE were not provided.

Flood depth rasters were extracted from HEC-RAS for the flood event's target flow rate. In ArcGIS Pro ModelBuilder, the rasters were quantified to a maximum depth integer value for the area surrounding each structure. The depth values were rounded up to the nearest integer, as rounding down was not appropriate for the results.

The residential building property data and inundation depths were utilized to assign a percent damage to the structures in the project area. The damage percentages for both pre- and post-structures are derived from FEMA's depth damage functions (DDF). The DDF includes data from national flood damage records and project-specific records. The DDF when graphed displays a relationship of the expected damage based on flood depth. Structural and content damage cost is calculated by multiplying the property value by the percent damage. The number of days displaced by a flood event is based on a FEMA regression curve that assigns the number of displacement days to the corresponding flood depth. A displacement cost is calculated by multiplying the number of days displaced by the current lodging per diem; with addition to the current meals per diem multiplied by both the number of people per household and number of days displaced. In the BCA tool, the total structural and content damages and displacement costs for pre- and post-mitigation data are entered with property location; hazard mitigation type; cost estimation; analysis duration; and annual social benefit, to calculate a benefit-cost summary and produce a corresponding BCR. This methodology generates BCRs for two discount rates: 3% and 7%. The 3% rate is appropriate only for projects expected to receive grant funding in the current cycle. The 7% rate is appropriate for projects with construction schedules further in the future. Only the BCRs using the 7% rate were used in these analyses.

The total mitigation project cost is estimated using a combination of estimated construction, operation, and maintenance costs. The total mitigation project benefit includes an estimate cost due of building damage, contents damage, displacement, and social losses.

The number of structures removed from inundation is related to the project benefit and represents the number of buildings in each alternative that are no longer expected to flood due to a reduced inundation boundary compared to the existing conditions inundation boundary. This reduction in inundated structures was evaluated for the 1% AEP flood event. 436 buildings were modeled to be inundated with great than 0 ft of flood water in existing conditions.

5.1.2.3 Critical Infrastructure Risk Reduction

The critical infrastructure of the project area considered includes the wastewater treatment plant (WWTP), fire station, Sheriff's Office, and emergency evacuation route (Canyon Way). The score assigned to each alternative represents an evaluation of the combined benefit observed at each of these locations. Depth times velocity (DV) Hazard Classifications were modeled and compared at the emergency stations and routes for the ranking of each alternative.

The WWTP inundation boundary extents were surprisingly sensitive to upstream mitigation locations such as SCW. Flood risk was found to decrease for all alternatives compared to existing, and benefit increased in the following alternative order: 5, 4, 3, 2, 1.

At the fire station, only minor reductions in Hazard Class are achieved by Alternatives 4 and 5. A moderate reduction in hazard is achieved with Alternative 3 in this location, while Alternatives 1 and 2 provide for a reduction of the Very High Hazard Class from this area.

At the Sheriff's Office and along Canyon Way toward I-80, Alternatives 4 and 5 provide only small reductions of flood hazard, with Very High and Extreme Hazard areas along Canyon Way. Alternative 3 shows a marked decrease in Hazard Class in this area, reducing from Extreme to High from the CDC Bridge northward. Similarly, the inundation boundary is reduced, moving flooding away from the Sheriff's Office. Alternatives 1 and 2, continue to reduce flood hazard in this location.

5.1.3 Additional Structural Recommendation: Removal of Channel Encroachments & Relocation and/or Protection of Overhead Utilities

The concrete barrier armored fill in the channel supporting overhead power lines near SCW and NCW should be removed to maintain existing flow capacity in the channel. Reducing the risk of failure of electric service will significantly reduce the indirect flood risk. Relocating overhead utility poles away from the channel, protecting them from erosion or debris strikes, or converting these overhead services to underground services is recommended, in coordination with other recommended alternatives if possible.

5.2 Non-Structural Mitigation Recommendations

Structural mitigation measures do not fully reduce the risks for the 1% AEP flood event and more severe storms. The following non-structural mitigation recommendations are intended to reduce flood risk by reducing the exposure of the population to flood hazard.

5.2.1 Develop and Regularly Exercise a Written Emergency Response Plan

Revise and document in writing a Flood Emergency Response Plan based on improved flood risk understanding and as structural or non-structural mitigation alternatives are implemented.

5.2.2 Warning and Notification Systems

Develop and revise warning and notification systems based on streamflow monitoring, precipitation forecasts, and observation of LVC. Consider supplementing the existing stream flow gauge on LVC (USGS gauge 10350100 on Long Valley Creek Near Happy Valley, NV) with additional gauges or developing and calibrating a hydrology model to be run in response to precipitation forecasts from the National Weather Service.

When flooding is expected, develop a diverse set of message delivery tools including modern and traditional methods. Delivery methods may include reverse 911 messaging, sirens and loudspeakers, or door-to-door notices. As part of the written emergency response plan, develop template messages that are concise, give clear direction in accessible, non-technical language, and are actionable without additional research needed by the affected public.

5.2.3 Refine and Enforce a Floodway or Other Floodplain Management Policies

The existing floodway does not appear to conform to intended community development patterns and does not appear to be serving its function as a regulatory tool. Consider revising the floodway based on planning structural and non-structural mitigation measures. Consider voluntary property purchases and conversion to open space or flood mitigation infrastructure for properties adjacent to LVC and subject to high flood risk.

5.2.4 Floodproofing, Building Stabilization, and Building Raises

Reduce the likelihood of floodwater intrusion and damage by floodproofing structures subject to flood risk. For structures in Moderate or higher Flood Hazard areas, evaluate the expected stability of the structure in response to buoyancy and high velocity flow. Should structures be found to be unstable, design and implement stabilization measures to prevent building movement and destruction. Consider raising buildings in areas of flood risk.

Floodproofing, stabilizing, or raising selected structures as a mitigating measure in conjunction with Alternatives 2 and 3 should be evaluated further.

6.0 Flood Hazard Mitigation Measures Implementation

Implementation and construction the recommended structural alternatives will likely begin with capital improvements planning and grant Identification. With funding sources identified, projects can be further planned and designed according to funding eligibilities, opportunities, and limitations.

6.1 Implementation Schedule and Sequencing

The implementation schedule will depend highly on available funding sources, but in general the sequence will consist of the following:

- Capital improvements planning & grant identification.
- Determination of grant requirements; refinement of preliminary design, likely permitting requirements, and construction costs; coordinate with and solicit input from the public.
- Begin grant application process; advance improvement design and construction documents to intermediate or issue for permit; estimate construction duration and evaluate likely bidding environment; identify detailed permitting requirements and engage with permitting agencies, plan or conduct environmental and cultural resources studies, begin preparation of environmental document; coordinate with and solicit input from the public.
- Manage awarded grants, continue to coordinate with permitting agencies, conduct or finalize environmental and cultural resources studies, advance or finalize environmental document.
- Advance design and construction documents to issue for bid status based on permitting and grant requirements; refine estimated construction duration and plan bid solicitation and construction periods.
- Solicit bids, manage construction, continue to manage grants.
- Grant documentation, reporting, and close-out.

6.2 Grant Considerations

Grant funding sources are expected to include the Nevada Department of Transportation, FEMA, and others. Grants may provide funding for planning, design, permitting, or construction, or some combination thereof. Many construction grants highly prioritize construction readiness or projects that are fully designed and permitted and can be constructed immediately following funding. The ability to leverage non-federal funding to satisfy match requirements is often essential or at least highly advantageous. Identification of federal grants, their match requirements, and eligible non-federal funding sources is recommended.

FEMA grants may be available to fund the Long Valley Creek Flood Mitigation efforts. The Flood Mitigation Assistance Grant Program requires a Flood Mitigation Plan to be developed in order to receive funding. FEMA chooses recipients based on the applicant's ranking of the project, eligibility, and cost-effectiveness of the project. Front loading the emergency infrastructure, access roads, and community benefits will optimize the grant selection. It is unknown whether grants for this project would be provided until the submittal and review processes are completed.

The schedule of this project will include sending the study to the state, applying for funding, and completing construction. The exact progress and completion of this project is unpredictable due to considered time of review, weather/availability of materials during construction, and funding availability. A schedule/milestone report will be created upon receiving more details from involved agencies.

6.2.1 Environmental and Permitting Considerations

Federal funding sources typically require National Environmental Policy Act (NEPA) permitting to be conducted for projects they fund. Since LVC is tributary to the federally jurisdictional Truckee River, USACE permits will be required for improvements at the confluence, and possibly upstream in LVC. Within the ordinary high-water mark (OHWM) along the Truckee River, the USACE exerts jurisdiction, and will permit construction following the 404 and possibly 408 processes. Other required permitting coordination is expected to include the Nevada Division of State Lands and the Nevada Division of Environmental Protection (NDEP). Depending on the extent and magnitude of construction, improvements may qualify under one of the many USACE 'Nationwide Permit' categories, which greatly simplify the application and review process. Even for Nationwide Permits, USACE permitting takes months at the shortest and can often take one or more years. Considering permitting strategy and schedule while planning construction improvements is recommended.

Cultural Resources evaluations will likely be required as part of the NEPA process. The requirements of evaluation and documentation will depend heavily on the age of the existing structure(s) to be modified, along with the presence or absence of known cultural resources in the vicinity.

Other state and local permitting efforts are expected to include coordination with the Nevada Department of Transportation and Canyon GID at a minimum.

7.0 Limitations

- These evaluations and cost estimates are based on preliminary and conceptual designs and are subject to change following improved understanding of site conditions and flood management strategy, advancement of designs, and regional construction costs.
- The scope of this study allowed for a limited number of evaluations of combinations of structural mitigation measures. Additional combinations may result in improved BCRs or other parameters.