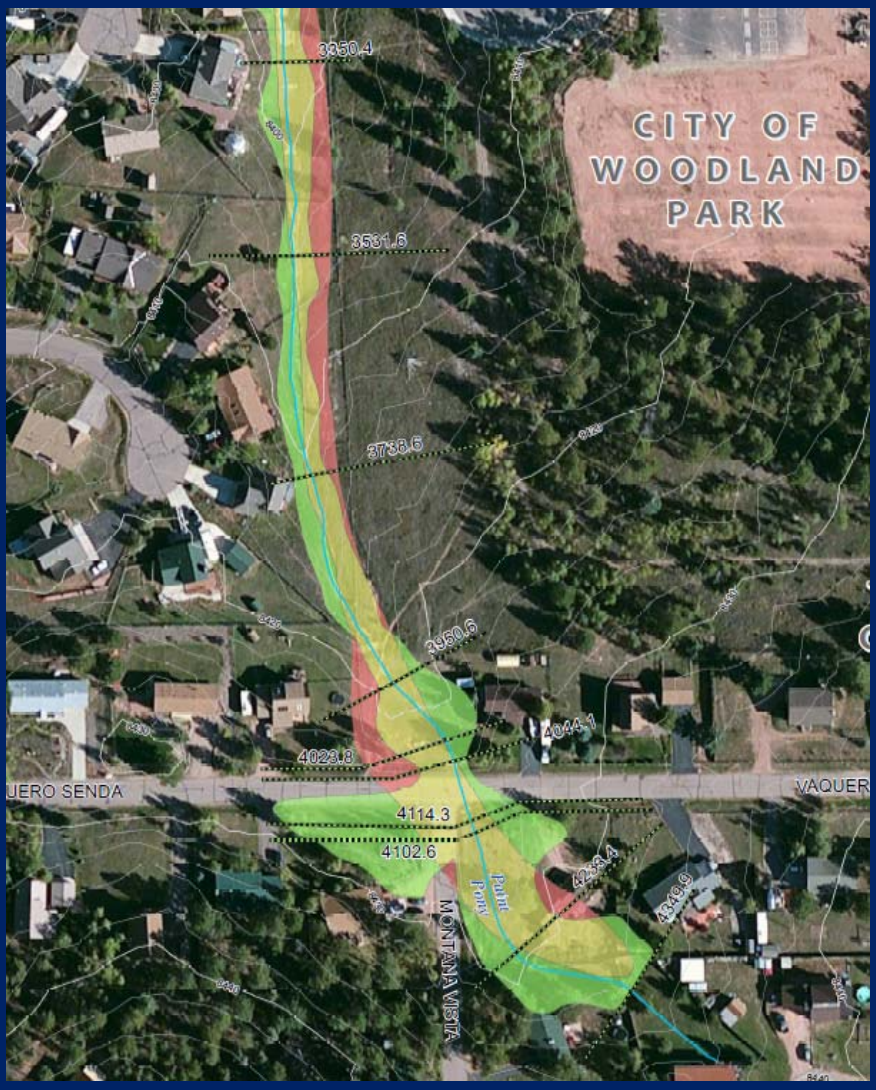
Michael Baker
INTERNATIONAL

Loy Gulch, Paint Pony, East Fork Paint Pony LOMR



Woodland Park, CO

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I. INTRODUCTION

1.1 Purpose

The City of Woodland Park, Colorado, is undertaking a multi-year project in order to update their comprehensive Stormwater Mater Plan. A core plan objective is to update select Flood Insurance Rate Maps (FIRMs) within Woodland Park using the effective FEMA hydrology. Through the planning process, Loy Gulch, Paint Pony, and East Fork Paint Pony have been identified as flooding sources that will be updated through the Letter of Map Change (LOMC) process. This Letter of Map Revision (LOMR) submittal has been compiled to update the effective FIRMs and Flood Insurance Study Report (FIS) for the Town of Woodland Park and Unincorporated Areas of Teller County, Colorado, for these identified flooding sources based on updated topographic data and updated hydraulic analyses.

1.2 Effective Studies

J.F. Sato and Associates, Inc. completed the hydrologic and hydraulic analyses for Loy Gulch, Paint Pony, and the East Fork Paint Pony in September 1985. On the Loy Gulch basin, the final drainage design developed by Aspen Engineering in April 1983 for Park View Estates was used as the basis for estimating flows above State Highway 67. These studies were initially published by FEMA in the Countywide Flood Insurance Study (FIS) for Teller County, Colorado and Incorporated Areas dated September 30, 1988. These studies where then incorporated and republished by FEMA in the Revised Countywide FIS dated September 25, 2009. The datum was updated from the National Geodetic Vertical Datum of 1929 (NGVD 29) to the North American Vertical Datum of 1988 (NAVD 88) but no additional modifications were made to the original studies.

Conditional Letter of Map Revision (CLOMR) Case# 08-08-0511R, effective December 8, 2009, was submitted to evaluate the effects of a proposed culvert, channel relocation, channelization, excavation, and fill would have on the effective flood study for Loy Gulch. After project construction was completed, an as-built LOMR Case# 10-09-0932P, effective November 17, 2011, was submitted to update the effective FIRM and FIS report for Loy Gulch based on updated topographic information and the as-built hydraulic analysis. It was later determined that there was a shift in the delineation of the effective floodplain for Loy Gulch which caused the revised floodplain produced by LOMR Case# 10-09-0932P to be shifted away from the actual channel location. As a result, LOMR Case# 14-08-0167P, effective March 26, 2015, was submitted to revised the affected portion of Loy Gulch from approximately 1,260 feet upstream of the confluence with Trout Creek to just Downstream of Research Drive. LOMR Case# 14-08-0167P superseded the entire revision reach of Case# 10-09-0932P and is currently the only effective LOMR or CLOMR that affects proposed revision areas.

1.3 Location and Scope

The City of Woodland Park is located within the northeastern portion of Teller County, Colorado, along the eastern boundary with El Paso County and is approximately 18 miles northwest of the City of Colorado Springs. This area is located within the eastern range of the Rocky Mountains and is encompassed by Pike National Forest. Woodland Park spans the divide between the Arkansas River Basin (Fountain Creek) and the South Platt River Basin to the north (Trout Creek). The elevation within Woodland Park ranges from approximately 8,000 feet on Fountain Creek to approximately 8,500 feet on the divide which is located near the center of the community.

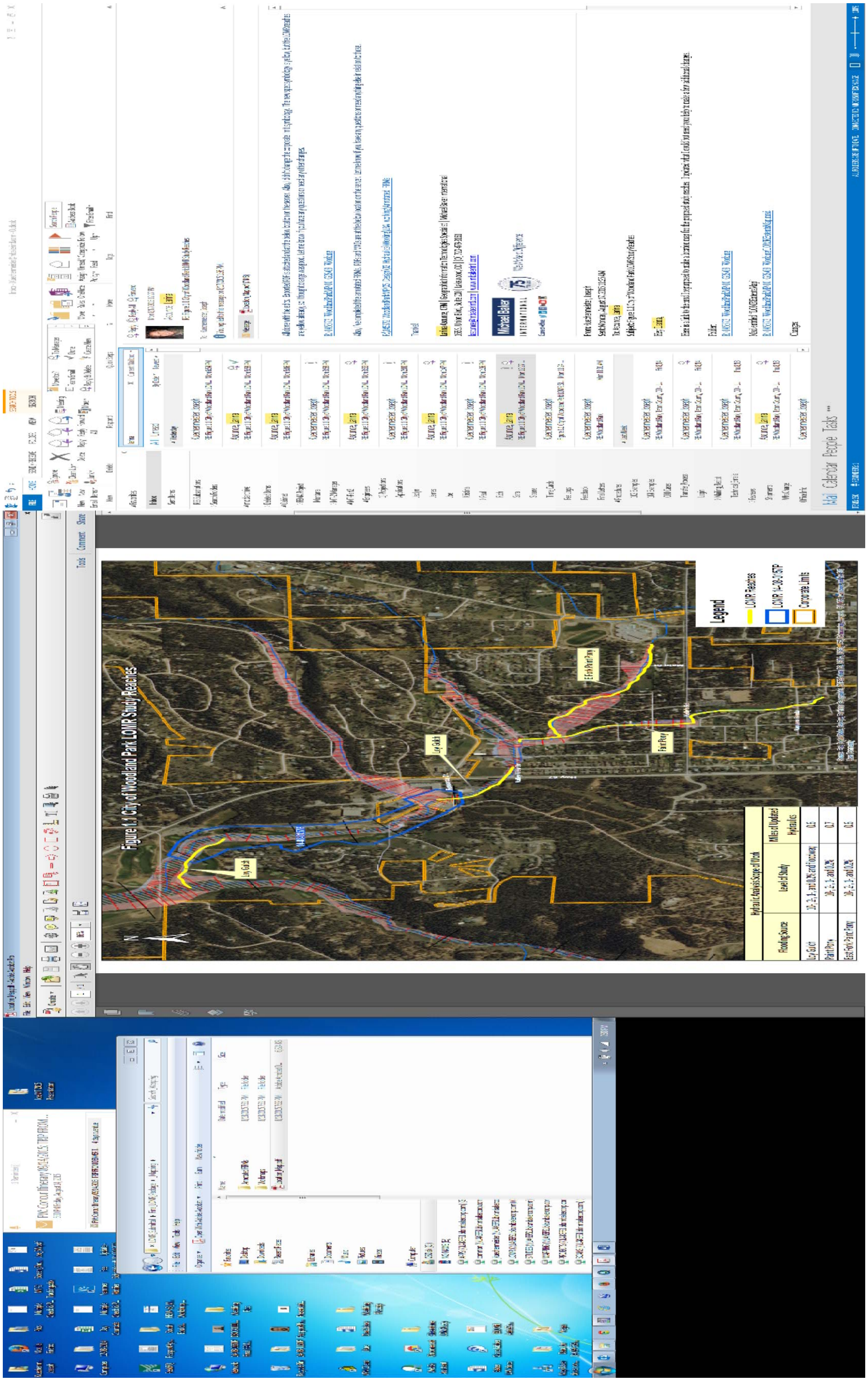
Figure 1: City of Woodland Park LOMR Study Reaches
Legend
LOMR Reaches
Corporate Limits

This LOMR application proposes to revise the following reaches based on updated topographic information and revised hydraulic analyses (see Figure 1.1 for approximate locations):

- Loy Gulch – from the confluence to approximately 1,647 feet upstream of the confluence with Trout Creek. The upstream end of the revision reach ties into the effective LOMR Case# 14-08-0167P.
- Loy Gulch – from approximately 187 feet downstream of Research Drive to approximately 338 feet upstream of State Highway 67. The downstream end of the revision reach ties into the effective LOMR Case# 14-08-0167P.
- Paint Pony – from the confluence with the Loy Gulch floodplain to the upstream limit of study.
- East Fork Paint Pony – from the confluence with Paint Pony to the upstream limit of study.

1.4 Topographic Mapping

The topographic data was provided by Landmark Mapping, LTD and was derived from a photogrammetric survey conducted on April 24, 2014. The final survey report submitted by ##### was dated #####. Two datasets with different vertical accuracies were collected. The main urbanized areas of Woodland Park were flown using a Light Detection and Ranging (LIDAR) system with a 2-foot vertical accuracy while the less populated areas of the City were covered with 5-foot vertical accuracy. A Topographic Data QC Review of this data was performed and the data was subsequently utilized to develop Digital Terrain Model (DTM) for use in the hydraulic model development. The projection of the data is StatePlane_Colorado_Central FIPS 0502 Feet, the horizontal datum is NAD 1983, and the vertical datum is NAVD 1988.

Projected Coordinate System: NAD_1983_StatePlane_Colorado_Central_FIPS_0502_Feet
Projection: Lambert_Conformal_Conic
Geographic Coordinate System: GCS_North_American_1983
Datum: D_North_American_1983

1.5 Structure Survey

Rampart Surveys, Inc. carried out ground surveys during December 2014 and May 2015. The final survey report submitted by Rampart Surveys, Inc. was May 15, 2015. Channel cross sections were surveyed upstream and downstream of all hydraulic structures within the revision reach. In addition, culvert geometries were surveyed in detail and the data was recorded through field notes and photographs. Spot elevations for all structure crossings, including structure inverts, were recorded and provided in a point shape file. All survey backup data, field drawing, notes, and photographs can be found in Appendix B of this report.

Surveyor: Rampart Surveys, Inc.
Survey Dates: 12/3/14 – 12/5/14 and 5/15/15
Horizontal Datum: NAD 1983 State Plane Colorado Central FIPS 0502 (Feet)
Vertical Datum: NAVD 88

II. HYDROLOGY

The discharges for the flood recurrence intervals having a 10-percent, 2-percent, 1-percent, and 0.2-percent chance of being equaled or exceeded in any given year, were obtained from the effective FIS for Teller County, Colorado and Incorporated areas dated September 25, 2009. The discharge values for this

FIS were established by the September 1985, J.F. Sato and Associates, Inc. hydrologic report titled *Hydrology Report for Flood Insurance Studies in Arapahoe, Douglas, and Teller Counties*. To develop a rainfall-runoff relationship, the U.S. Soil Conservation Service (SCS) TR-20 computer program was used [U.S. Department of Agriculture, Soil Conservation Service, May 1983]. In addition, previous hydrologic studies were used in developing the final hydrologic discharges presented in the above referenced report.

The initial discharge values for each flooding source were obtained from the effective FIS Summary of Discharge Table 2. In addition, the effective HEC-2 hydraulic models were reviewed to determine if additional flow change locations were incorporated into the effective analysis that were not reported in the Summary of Discharge Table 2. This review determined that one additional discharge change location was available for East Fork Paint Pony. It was also verified that all applicable discharge change locations for Loy Gulch were published in the FIS report. After a comprehensive search of the FEMA Library, Mapping Information Platform (MIP), and data request to the City of Woodland Park; it was determined that a copy of the effective HEC-2 modeling for Paint Pony was unavailable. However, the two discharge locations published in the FIS were deemed sufficient to update the hydraulic analysis for Paint Pony.

Table 2.1 – Effective FIS Discharges

		Peak Discharges (Cubic Feet Per Second)			
Flooding Source and Location	Drainage Area (Square Miles)	10-Percent-Annual-Chance	2-Percent-Annual-Chance	1-Percent-Annual-Chance	0.2-Percent-Annual-Chance
Loy Gulch					
Just West of Highway 67	5.2	240	690	1,040	1,970
At Confluence with Lovell Gulch	4.3	230	630	930	1,720
East Fork Paint Pony					
At Confluence with Paint Pony	0.7	70	200	290	490
At Confluence with unnamed tributary	0.5	35[1]	100[1]	145[1]	245[1]
Paint Pony					
At Confluence with Loy Gulch	1.1	110	280	410	670
At Confluence with East Fork Paint Pony	0.4	40	80	120	180

[1]Discharge obtained from effective HEC-2 model printout

III. HYDRAULIC MODELING

3.1 Model Development Overview

A comprehensive search was conducted to obtain copies of the effective hydraulic modeling for Loy Gulch, Paint Pony, and East Fork Paint Pony. The initial data search of the MIP produced printouts for the effective HEC-2 hydraulic model input and output values for Loy Gulch and the East Fork Paint Pony. In addition, copies of the effective HEC-RAS hydraulic modeling from effective LOMR Case# 14-08-0167P were available for download from the MIP; however, a copy of the effective modeling for Paint Pony was unavailable. An additional search of the FEMA Library through an external data request also failed to yield a copy of the Paint Pony effective model. A request was also submitted to the City of Woodland Park in an attempt to determine if a copy of the effective Paint Pony modeling was available in the community archives but the community was also unable to locate this data.

Ideally digital copies of the effective hydraulic modeling would be available for use in producing duplicate effective models for the proposed revision reaches. In this case, the copies of the effective hydraulic models were only available in hard copy format for Loy Gulch and the East Fork Paint but an

effective copy of the Paint Pony hydraulic model was unavailable. The age of the effective analyses indicates that they are outdated and no longer represent current existing conditions. In addition, this LOMR request is based solely map changes based on flood hazard information meant to improve upon that shown on the flood map or within the flood study without incorporating any proposed man made changes. Therefore, it was determined that producing duplicate effective models for these flooding sources would provide minimal benefit so duplicate effective models were not produced. However, a duplicate effective model was created for the effective HEC-RAS hydraulic modeling from effective LOMR Case# 14-08-0167P. Copies of all the available effective hydraulic models are provide in Appendix C of this report.

Existing conditions hydraulic models for Loy Gulch, Paint Pony, and East Fork Paint Pony were produced using the U.S. Army Corps of Engineers (USACE) HEC-RAS program, version 4.1. Cross section geometry for the revision reaches was cut from a Triangulated Irregular Network (TIN) digital terrain model using the USACE HEC-GeoRAS program, Version 10.1, and input into HEC-RAS for detailed model development. Culvert geometries and locations were recorded by Rampart Surveys, Inc. through survey data, photographs, and field notes. This data was used to manually enter culvert data into the HEC-RAS models. At the upstream and downstream ends of all hydraulic structures, surveyed channel cross section information was incorporated into the georeferenced cross section geometry that was collected with HEC-GeoRAS.

Manning's 'n' roughness values were evaluated using photographs taken by Rampart Surveys, Inc. and aerial imagery. The channel 'n' values were set to 0.035 for all modeled reaches and were based on channel integrity and stream bed composition. The overbank 'n' values were set from 0.014 to 0.06 depending on the specific land use and vegetation density. These values were deemed to be realistically conservative and are in agreement with the effective detailed study. A land use shape file was created in HEC-GeoRAS and attributed with Manning's 'n' values according to the specific land use. This allowed the HEC-RAS cross sections to be automatically attributed with the appropriate Manning's 'n' values when creating model cross sections within HEC-GeoRAS.

The majority of the studied flooding sources pass through residential areas within the City of Woodland Park. In order to capture potential obstructions to flow, a shape file was created in HEC-GeoRAS to capture the locations of all structures near or within the floodplain. This allowed the location and extent of potential flow obstructions to be automatically captured within the model cross section geometry when creating model cross sections within HEC-GeoRAS. The Manning's 'n' values were chosen according to the specific land uses but the incorporation of blocked obstructions within the modeling was used to simulate flood behavior within the residential areas. Care was taken when placing cross sections to capture the full extent of flow obstruction in order to ensure the modeling results were representative of actual flow conditions within these residential areas.

All the HEC-RAS hydraulic models were executed under the assumption of subcritical flow to produce the most conservative water surface elevations.

3.2 Loy Gulch – Downstream Golf Course Reach

In order to correct significant shifts in the effective floodplain and floodway delineation, the downstream end of Loy Gulch was selected for revision through this LOMR submittal. The revision reach of Loy Gulch begins at the confluence with Trout Creek and ends approximately 1,647 feet upstream of the confluence with Trout Creek. The updated analysis revealed that the effective floodplain does not currently coincide with the location of the low flow channel. In addition, the actual confluence with Trout Creek doesn't coincide with the effective confluence location.

The area of the Loy Gulch downstream revision is covered by topographic data with a 5-foot contour interval level of accuracy. This is the only revision reach that uses the 5-foot contour topographic data. The effective hydraulic analysis was based on topographic mapping with a 5-foot contour interval so this updated LOMR analysis matches the topographic resolution that was used in the effective analysis. A HEC-RAS hydraulic analysis was completed which incorporated the effective hydrology and the updated topographic data. The HEC-RAS modeling incorporated the same recurrence intervals studied in the effective FIS which included the 10-percent, 2-percent, 1-percent, and 0.2-percent chance of being equaled or exceeded in any given year, as well as a floodway. The starting boundary condition was set to normal depth and the channel slope was calculated between the most downstream model cross sections.

A floodway analysis was performed for this study reach and is included in the corresponding HEC-RAS models as a separate plan. Initial floodway runs were performed using Method 1 with the equal conveyance option turned on and a target rise in water surface elevation of 0.5 foot. The Method 1 results were input into Method 4 and negative surcharges and surcharges greater than 0.5 foot were removed by manually adjusting the encroachment stations.

During model construction, it was observed that the low flow channel may not have the capacity to convey the entire 100-year flow so a lateral weir was incorporated on the northern (right) overbank using HEC-GeoRAS. Weir coefficients were set to be within the range of acceptable values given in the document "Combined 1D and 2D modeling with HEC-RAS" by the USACE HEC (Hydraulic Engineering Center) in August 2013. These recommended values are lower than values that have been recommended in the past, but are backed up by testing by HEC that revealed that weir coefficients for lateral weirs should be lower than the generally accepted values for inline weirs. The lateral weir was optimized in order to calculate the discharge for a split flow that breaks out of the main channel and travels to the northwest. The 100-year discharge in the split was minimal so the split flow floodplain can be mapped as Shaded Zone X shallow flooding. However, flow splits out to the north during the 500-year flood event so a separate reach was incorporated into the HEC-RAS model to determine the extents of the Shaded Zone X split flow floodplain based on the calculated 500-year split flow. A separate flow calculation plan was incorporated into the HEC-RAS model which contained the lateral weir flow optimization calculations. An additional regulatory plan was then created in the HEC-RAS model where discharge estimates for the split flow were hard coded into the model.

In order to achieve a tie-into the effective study for Loy Gulch at the upstream end of the revision reach, the effective geometry for Cross Section 400 from effective LOMR Case# 14-08-0167P was incorporated into the HEC-RAS hydraulic modeling. Cross Section 400 was selected as the upstream tie-in location because the effective floodplain coincided with the physical channel location in this area. Effective cross sections that were downstream of this location did not accurately represent the existing ground geometry so a graphical tie into the effective floodplain could not have been achieved.

A check was performed to ensure the updated modeling tied back into the effective analyses at the upstream end of the revision reach. This review showed that all modeled recurrence intervals tie back into their effective water surface elevations (WSEL) well within the 0.5 foot tolerance. The actual tie-in for the 100-year WSEL was within 0.00 foot at the upstream location.

3.3 Loy Gulch – Upstream Reach

In order to correct significant shifts in the effective floodplain and floodway delineation, a reach of Loy Gulch upstream of effective LOMR Case# 14-08-0167P was selected for revision through this LOMR

submittal. This revision reach of Loy Gulch begins approximately 187 feet downstream of Research Drive and ends approximately 338 feet upstream of State Highway 67.

This area of the Loy Gulch is covered by topographic data with a 2-foot contour interval level of accuracy. A HEC-RAS hydraulic analysis was completed which incorporated the effective hydrology, updated topographic data, and hydraulic structure survey data. The HEC-RAS modeling incorporated the same recurrence intervals studied in the effective FIS which included the 10-percent, 2-percent, 1-percent, and 0.2-percent chance of being equaled or exceeded in any given year, as well as a floodway. The starting boundary condition was set to the known water surface elevations that were obtained from effective profile 13P which was revised by effective LOMR Case# 14-08-0167P.

A floodway analysis was performed for this study reach and is included in the corresponding HEC-RAS models as a separate plan. Initial floodway runs were performed using Method 1 with the equal conveyance option turned on and a target rise in water surface elevation of 0.5 foot. The Method 1 results were input into Method 4 and negative surcharges and surcharges greater than 0.5 foot were removed by manually adjusting the encroachment stations.

In order to achieve a tie-into the effective study for Loy Gulch at the upstream end of the revision reach, the effective geometry for FEMA Lettered Cross Section G was incorporated into the HEC-RAS hydraulic modeling. The effective Cross Section G was selected as the upstream tie-in location because the effective floodplain coincided with the physical channel location in this area. Cross Section G corresponds to section number 6000.000 in the effective HEC-2 model printout for Loy Gulch. The effective datum shift of +4.2 feet (NGVD 29 + 4.2 feet = NAVD 88) was applied to vertical elevations in order to match the currently effective vertical datum of NAVD 88.

A final check was performed to ensure the updated modeling tied back into the effective analyses at the upstream and downstream ends of the revision reach. This review showed that all modeled recurrence intervals tie back into their effective water surface elevations (WSEL) well within the 0.5 foot tolerance. The actual tie-in for the 100-year WSEL is within 0.00 foot at both locations.

3.4 Paint Pony

Through the planning process, it was determined that Paint Pony was due for an updated hydraulic analysis. As a result, the entire effective reach of Paint Pony was restudied starting from the confluence with the Loy Gulch floodplain and ending at the effective upstream limit of study. The upstream reach of Paint Pony was mapped as an approximate Zone A floodplain and this analysis proposes to update the entire reach to a detailed study.

The revision reach for Paint Pony is covered by topographic data with a 2-foot contour interval level of accuracy. A HEC-RAS hydraulic analysis was completed which incorporated the effective hydrology, updated topographic data, and hydraulic structure survey data. The HEC-RAS modeling incorporated the same recurrence intervals studied in the effective FIS which included the 10-percent, 2-percent, 1-percent, and 0.2-percent chance of being equaled or exceeded in any given year. No effective floodway was present for Paint Pony and a floodway is not being added as part of this LOMR submittal. The starting boundary condition was set to normal depth where the channel slope was calculated between the most downstream model cross sections.

The updated analysis showed that the 100-year floodplain is mainly contained in the channel for the upper portions of Paint Pony. All the culverts along this reach are undersized which cases backwater upstream of the culvert and overtopping of the roadways.

The currently effective analysis indicates that the detention basin at Kelly's Road overtops during the 100-year flood event. However, the updated analysis showed that the majority of the 100-year discharge can be conveyed within the detention basin outlet at Kelly's Road. The 100-year floodplain does overtop Kelly's Road but the flow depths are less than 1 foot average depth so the overflow floodplain can be mapped as Shaded Zone X shallow flooding. A separate HEC-RAS model was run to determine the extents of the Shaded Zone X for the Paint Pony Overflow floodplain and the floodplain limits were based on the 500-year flood discharge that weir flows over Kelly's Road. The Paint Pony Overflow rejoins the main channel of Paint Pony at the location of the downstream detention basin outlet.

Further downstream at the confluence with East Fork Paint Pony, the channel does not have the capacity to convey the entire 100-year flood discharge. A lateral weir was incorporated on the western (left) overbank to calculate the discharge for a split flow that breaks out of the main channel and travels to the west. The flow leaves the main channel as shallow flooding and forms a split flow reach called Paint Pony Split that runs along Chippewa Trail and parallel to Paint Pony. The 100-year flow depths that break out from Paint Pony are less than 1 foot average depth so the Paint Pony Split floodplain can be mapped as Shaded Zone X shallow flooding. The Paint Pony Split rejoins with Paint Pony and Loy Gulch combined floodplain at the Chippewa Trail culvert. The drainage ditch that forms Paint Pony Split doesn't have the capacity to convey the entire split flow discharge so another lateral weir was added to the model on the western (left) overbank to calculate the discharge for the second split flow called Paint Pony Split 2 which breaks out to the west. The 100-year flow depths that break out from Paint Pony Split are less than 1 foot average depth so the Paint Pony Split 2 floodplain can be mapped as Shaded Zone X shallow flooding. The shallow flooding split flow travels to the west before turning northwest upstream of Columbine Village Drive where it can rejoin Point Pony and Loy Gulch through culverts under Valley View Drive and/or overtopping the roadway. Separate reaches for the Paint Pony Split flows were modeled in HEC-RAS to determine the extents of the Shaded Zone X split flow floodplains which were based on the extents of 500-year floodplain. A separate flow calculation plan was incorporated into the HEC-RAS model which contained the lateral weir flow optimization calculations. Weir coefficients were set to be within the range of acceptable values given in the document "Combined 1D and 2D modeling with HEC-RAS" by the USACE HEC (Hydraulic Engineering Center) in August 2013. An additional regulatory plan was then created in the HEC-RAS model where discharge estimates for the split flow were hard coded into the model.

When running the weir flow optimization HEC-RAS plan for the lateral weirs along Paint Pony, it was observed that the flow values did not converge for some of the modeled recurrence intervals. We believe this lack of convergence is due to the model's complexity associated with incorporating multiple lateral weirs that occur at different elevations. However, efforts to make the model converge for all recurrence intervals while not reducing the fidelity of the model (particularly for the 100-year flood) have been reasonably successful. Specifically, combinations of larger calculation tolerances were programmed into the HEC-RAS model such as increasing the water surface calculation tolerance, increasing the critical depth calculation tolerance, and increasing the flow tolerance factor in weir split flow were all attempted. It is possible to make all the modeled recurrence intervals converge by maxing out these tolerances, but the model becomes less precise. The precision of the model is especially critical for determining the discharges of the split flows, and we believe that the model is producing reasonable results even though it does not converge for all modeled recurrence intervals. Therefore, we made the decision to minimally adjust the calculation tolerances until the 100-year and 500-year flows converged. This resulted in a model that converged for all recurrence intervals with the exception of the 50-year flood.

The effective analysis assumed that Loy Gulch and Paint Pony shared coincident flood peaks. As a result, the effective analysis models a combined floodplain for Loy Gulch and Paint Pony from Pautte Trail (were the floodplains combine) to the confluence with the Paint Pony channel. Revising Loy Gulch is

outside the scope of this LOMR revision so Paint Pony was modeled independently of Loy Gulch by setting the starting boundary condition for Paint Pony to normal depth and the channel slope was calculated between the most downstream model cross sections. This allowed the Paint Pony WSELs to be calculated without the consideration of backwater from Loy Gulch. This approach does not require a WSEL tie-into the effective Loy Gulch profile and the backwater from Loy Gulch will be manually added to the downstream end of the profile for Paint Pony. In addition, this updated analysis completely restudies the entire reach of Paint Pony so there is no upstream WSEL tie-in to consider.

3.5 East Fork Paint Pony

Through the planning process, it was determined that East Fork Paint Pony was due for an updated hydraulic analysis. As a result, the entire effective reach of East Fork Paint Pony was restudied starting from the confluence with Paint Pony and ending at the effective upstream limit of study.

The revision reach for East Fork Paint Pony is covered by topographic data with a 2-foot contour interval level of accuracy. A HEC-RAS hydraulic analysis was completed which incorporated the effective hydrology, updated topographic data, and hydraulic structure survey data. The HEC-RAS modeling incorporated the same recurrence intervals studied in the effective FIS which included the 10-percent, 2-percent, 1-percent, and 0.2-percent chance of being equaled or exceeded in any given year. No effective floodway was present for East Fork Paint Pony and a floodway is not being added as part of this LOMR submittal. The starting boundary condition was set to normal depth and the channel slope was calculated between the most downstream model cross sections.

The updated analysis showed that the 100-year floodplain is mainly contained in the channel for the upper portions of East Fork Paint Pony. All the culverts along this reach are undersized which causes backwater upstream of the culverts and overtopping of the roadways. In some instances, the downstream internal structure cross sections within HEC-RAS show extended water surface elevations when compared to the ground geometry and road deck. The upstream channel geometry indicates that the overtopping flow would be concentrated around the channel location and indicates that the flow momentum would cause the majority of the overtopping flow to continue downstream to rejoin the stream channel. In each case, the depth of the 100-year floodplain is less than 1.0 foot average depth which indicates any potential breakout flow would ultimately be mapped as Shaded Zone X floodplain. In addition, any shallow flooding that escaped from the main channel would likely be contained in existing drainage diches or storm drains. This indicates that the current modeling approach is reasonable and provides an accurate representation of the flood hazard for flow that overtops these culverts.

It was assumed that Paint Pony and East Fork Paint Pony did not share coincident flood peaks. As a result, the starting boundary condition for East Fork Paint Pony was set to normal depth and the flood elevations were calculated without the consideration of backwater from Paint Pony. The channel slope for the normal depth boundary condition was calculated between the most downstream model cross sections. This approach does not require a WSEL tie-into the effective Paint Pony profile and the backwater from Paint Pony will be manually added to the downstream end of the profile for East Fork Paint Pony. In addition, this updated analysis completely restudies the entire reach of East Fork Paint Pony so there is no upstream WSEL tie-in to consider.

IV. FLOOD HAZARD MAPPING

4.1 Flood Hazard Mapping Overview

The HEC-RAS model output was imported into the HEC-GeoRAS program to generate floodplain boundaries for the 1-percent and 0.2-percent annual chance floods. Cross sections from the final HEC-RAS models were attributed with 1%- and 0.2%-annual-chance-flood water surface elevations and were intersected with the TIN in HEC-GeoRAS to delineate 'first-cut' floodplain boundaries. The first cut boundaries were reviewed and refined manually to accurately reflect the results of the hydraulic models. Quality control was performed to remove small islands, smooth out the 1%- and 0.2%-annual-chance event floodplain delineations, and ensure logical tie-ins to the effective floodplains at the upstream and downstream ends of the revision reaches. In some cases, engineering judgement was used to ensure the mapped floodplain boundaries accurately represented the flood hazards for each flood event.

For revision reaches that involved a floodway revision, the final encroachment stations from the HEC-RAS modeling were imported into ArcGIS through HEC-GeoRAS. The floodway was then manually delineated between modeled cross sections using engineering judgment and to ensure a smooth floodway delineation.

4.2 Loy Gulch – Downstream Golf Course Reach

The updated hydraulic analysis indicated that the physical confluence with Trout Creek did not corresponded to the confluence location shown in the effective FIRM and FIS report. As a result, the effective floodplain boundaries on the right overbank of Trout Creek were redelineated based on effective Base Flood Elevations (BFEs) and the updated topographic contours. The backwater from Trout Creek was mapped over the downstream end of Loy Gulch to achieve a graphical tie-into the updated effective delineation.

The resulting boundary of the 500-year floodplain was narrower than the currently effective 500-year floodplain. However, the Loy Gulch Split to the north indicated that the 500-year floodplain should be delineated conservatively in this area. In addition, the modeling results indicate that there is the potential for more breakout flows for 500-year flood event on the right overbank at HEC-RAS Cross Section 224.6924. It is recommended that the intersection between the Loy Gulch Split and the effective floodplain boundary for the 500-year floodplain is used as the tie-in location for this flood event. This would maintain a conservative floodplain delineation near the confluence with Trout Creek. Because the Loy Gulch Split will be mapped as Shaded Zone X, it is recommended that the streamline and cross section are not added to the annotated FIRM.

The upstream end of Loy Gulch formed a graphical tie-into the effective study at Cross Section 400 from effective LOMR Case# 14-08-0167P. The graphical tie-in was reviewed to ensure the 100-year floodplain, 500-year floodplain, and floodway tied back into the effective delineations within 5% of the effective FIRM scale or 25 feet for the 500 scale FIRM. This review showed the floodplains and floodway tie back into the effective delineation at the modeled cross section within tolerance at the upstream end of the revision. However, the floodplain shape files were extended past the modeled cross sections to produce a smooth transition back to the effective floodplain delineations.

4.3 Loy Gulch – Upstream Reach

The downstream end of this reach of Loy Gulch ties into the effective floodplain and floodway delineation of effective LOMR Case# 14-08-0167P. This location was chosen because the channel was incised which indicated that the effective floodplain delineation could be reproduced when the starting boundary condition was set to the known water surface elevation. An updated HEC-RAS cross section was cut from the TIN in this location and the known water surface elevations were obtained from the annotated profile 13P which was produced by effective LOMR Case# 14-08-0167P.

In order to achieve a tie-into the effective study for Loy Gulch at the upstream end of the revision reach, the effective geometry for FEMA Lettered Cross Section G was incorporated into the HEC-RAS hydraulic modeling. The effective Cross Section G was selected as the upstream tie-in location because the effective floodplain coincided with the physical channel location in this area.

The resulting 100-year floodplain, 500-year floodplain, and floodway that tied back into the effective delineations within 5% of the effective FIRM scale or 25 feet for the 500 scale FIRM. The floodplains and floodway delineations tie back into the effective delineation at modeled cross sections on the upstream and downstream ends of the revision. However, the floodplain shape files were extended past the modeled cross sections to produce a smooth transition back to the effective floodplain delineations.

At the upstream end of this revision, it appears that the effective streamline does not coincide with the location of the channel. In order to correct this discrepancy without impacting the updated analysis, the revised streamline was extended upstream to tie into the effective streamline at a location that falls within the stream channel. The updated streamline has minimal impact on the reach length when compared to the effective (less than 1 foot difference) so it should have negligible impacts on the effective reach lengths.

4.4 Paint Pony

The effective analysis modeled a combined floodplain for Loy Gulch and Paint Pony starting at Pautte Trail. As a result, this location was chosen as the downstream tie-in location for the Paint Pony floodplain. The modeling for Paint Pony started at normal depth so the floodplain could be defined without influence from Loy Gulch at the confluence. The BFEs from Loy Gulch and Pant Pony were compared at the floodplain confluence and the more conservative BFE was used to delineation the 100-year floodplain delineation. This results in backwater from Loy Gulch being mapped over the downstream end of the Paint Pony floodplain at the confluence. The effective Zone AE floodplain delineation for the combined Loy Gulch/Paint Pony floodplain was redelineated based on effective BFEs and updated topographic information. The 500-year floodplain delineation forms a tie-into the effective delineation where the two floodplains intersect. The intersection of the effective and revised 500-year floodplain delineations were smoothed to produce a more reasonable transition.

The effective streamline for Paint Pony doesn't correspond with the location of the stream channel. An updated streamline was produced that follows the Paint Pony channel to the confluence with the Loy Gulch channel. This updated streamline intersects with the revised section of streamline for Loy Gulch that is described in the previous section. The combined Loy Gulch/Paint Pony floodplain references the Loy Gulch streamline for profile stationing so updating the Pant Pony streamline would not influence the effective profile for this reach.

The floodplains for Paint Pony Split and Paint Pony Split 2 are mapped as shallow flooding Zone X shaded based on the calculated 500-year flood discharges. The updated 500-year floodplain delineation

forms a tie-into the effective 500-year delineation where the two floodplains intersect. The intersection of the effective and revised 500-year floodplain delineations were smoothed to produce a more reasonable transition. At the downstream end of Paint Pony Split 2, the 500-year floodplain delineation was mapped conservatively to show the flow overtopping Valley View Drive in order to combine with the Loy Gulch floodplain. Because the Paint Pony Splits will be mapped as Shaded Zone X, it is recommended that the streamlines and cross sections are not added to the annotated FIRM.

Further upstream on Paint Pony, a separate HEC-RAS model was run to determine the extents of the Paint Pony Overflow floodplain for flow that overtops the detention basin at Kelly's Road. The 100-year floodplain does overtop Kelly's Road but the resulting shallow flooding has average depths less than 1.0 foot so the Paint Pony Overflow can be mapped as a Shaded Zone X floodplain. The floodplain limits were based on the 500-year flood discharge that weir flows over Kelly's Road and the floodplain delineation was smoothed based on engineering judgement. The Paint Pony Overflow rejoins the main channel of Paint Pony at the location of the downstream detention basin outlet.

This updated analysis completely restudies the entire reach of Paint Pony so there is no upstream floodplain tie-in to consider.

4.5 East Fork Paint Pony

The modeling for East Form Paint Pony stated at normal depth so the floodplain could be defined without influence from Paint Pony at the confluence. The BFEs from East Fork Paint Pony and Pant Pony were compared at the confluence and the more conservative BFE was used to delineation the 100-year floodplain delineation. This resulted in a smooth transition between floodplains at the confluence and produced a conservative floodplain delineation. A similar procedure was followed when delineating the floodplain for the 500-year flood.

The updated analysis for East Fork Paint Pony completely restudies the entire effective reach so there is no upstream floodplain tie-in to consider.

V. CONCLUSION

Based on the above discussion and documentation included in this report, we believe that this project is in compliance with FEMA regulations for a Letter of Map Revision request for map changes based on flood hazard information meant to improve upon that shown on the effective FIRM and FIS report. Any questions concerning this LOMR submittal should be addressed to Joe Kuechenmeister, P.E., CFM, by phone at (720)479-3181 or by email JKuechenmeister@mbakerintl.com.