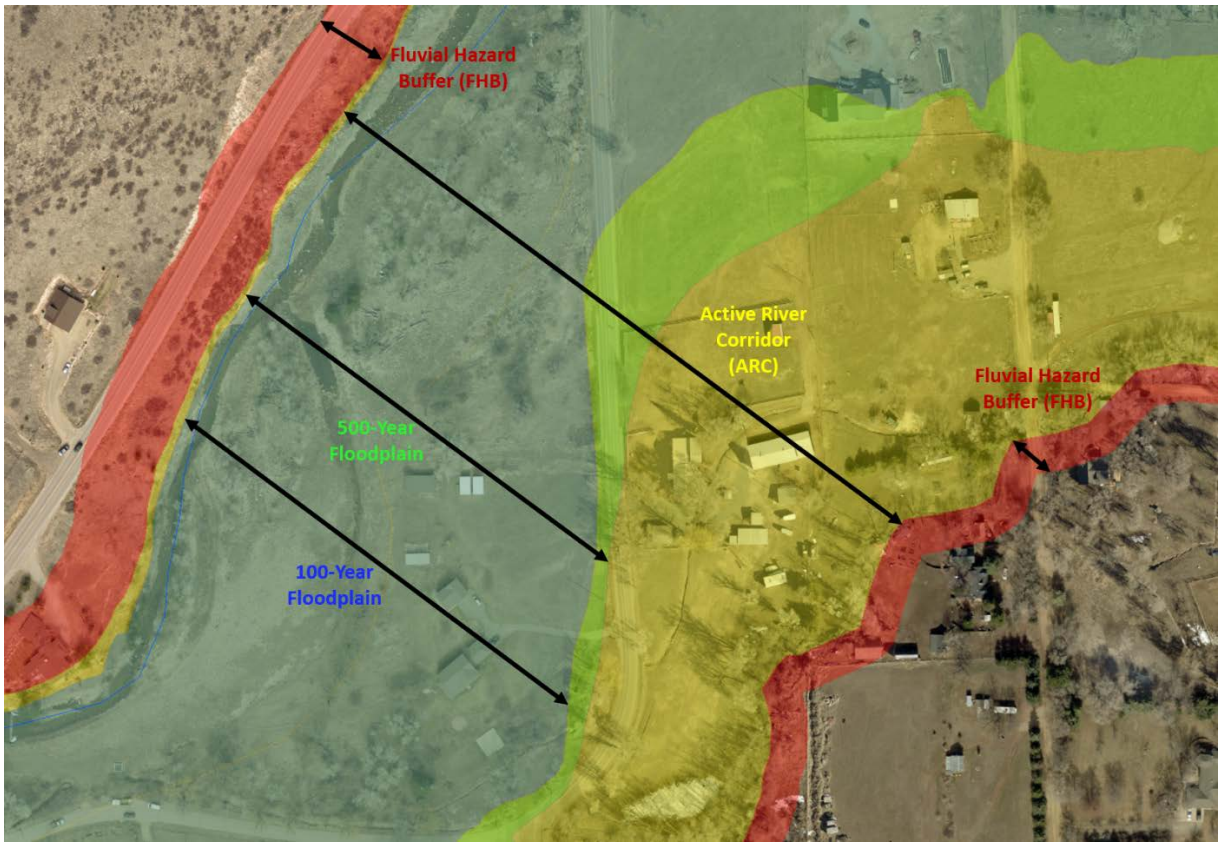
Boulder County Fluvial Hazard Zone Integration Pilot

Final Report



Prepared for:
Colorado Water Plan Grant Program
Attn: Chris Sturm

June 29, 2022

Boulder County
Grant Amount: $30,000
Prepared by:
Community Planning & Permitting Department, Floodplain Management Program
& Lynker Technologies

Contents

Introduction

Boulder County is committed to developing goals, policies, and practices that reduce the impacts of major flooding. The catastrophic floods of 2013 demonstrated that flood damage can occur outside of the county's regulatory floodplain as a result of fluvial hazards such as erosion, deposition, and debris transport. Conventional floodplain maps, such as the FEMA Flood Insurance Rate Maps (FIRMs), do not fully account for these fluvial geomorphic processes and are therefore incomplete representations of flood risk in Boulder County. In order to reduce the impacts of major flooding, the county must understand fluvial geomorphic hazards, educate the public on fluvial hazards, and incorporate appropriate fluvial hazard mitigation strategies into its existing goals, policies, and practices. The county participated as a pilot community in the Colorado Water Conservation Board's Fluvial Hazard Zone (FHZ) Mapping Program and has received FHZ delineations for its most mobile perennial stream reaches. The purpose of this project, executed by the Floodplain Management Program in the Community Planning & Permitting Department, were 1) to better understand the FHZ data products in the context of other delineations of flood risk in the County; and 2) to integrate FHZ mapping data and FHZ management guidance into the county's comprehensive planning, development review, and hazard mitigation goals, policies, and practices.

The Floodplain Management Program is responsible for enforcing county flood protection regulations within 11,000 acres of regulatory floodplain, over 60% of which is preserved as open space. This includes permitting new development to minimize flood risk and preserve natural floodplain function. In addition, the program updates and maintains flood hazard data, informs policymaking related to flood hazard mitigation, and establishes short and long-term flood hazard mitigation goals.

Background and Methods

The motivation for this project stemmed from two previous pilot projects. The first was the Colorado Water Conservation Board's FHZ Mapping Program, which worked with Boulder County to identify stream reaches in the unincorporated county that have a history of lateral migration. The program provided spatial data and FHZ mapping for these reaches. The study area for this project coincides with the reaches included in the FHZ Mapping Program for unincorporated Boulder County:

- North Saint Vrain Creek from Rainbow Bridge at the upstream end of Apple Valley to the Town of Lyons municipal boundary;
- South Saint Vrain Creek from the canyon mouth (near the Andesite Quarry) to the Town of Lyons municipal boundary;
- Saint Vrain Creek from the eastern Town of Lyons municipal boundary to the western City of Longmont municipal boundary;
- Left Hand Creek from Buckingham Park to the southern City of Longmont municipal boundary;
- Six Mile Creek from Valley Lane to its confluence with Left Hand Creek in Buckingham Park;
- South Boulder Creek from the Mesa Trail South Trailhead to the confluence with Boulder Creek; and
- Boulder Creek from the confluence with South Boulder Creek to the Boulder/Weld County line.

The second motivating study for this project was a recently-completed FEMA Flood Mitigation Assistance (FMA) Grant-funded pilot project to evaluate the eligibility of interested Boulder County residents for FMA grants to elevate their homes. To be eligible for FMA, FEMA requires elevation projects above a certain cost to have a Benefit Cost Ratio (BCR) of one or greater, as calculated using FEMA's Benefit Cost Analysis Toolkit. Lynker Technologies (Lynker) provided technical support to the county by calculating the BCR for each participating structure and for other structures that were known to have experienced damage in the major flood of 2013. We found that elevating many of the structures that had been substantially damaged by flooding, particularly those in mountainous areas, would not meet the minimum BCR to be eligible for FMA. This is because the Benefit Cost Analysis Toolkit assumes that flood damage is strictly a function of flooding depth. The Toolkit, like the FIRMs, cannot predict the likelihood of damage from fluvial geomorphic processes. So, a primary motivation behind this Fluvial Hazard Zone Integration pilot project was to leverage available FHZ data as an alternative means of demonstrating flood risk for structures exposed to fluvial hazards.

Task One

This project was split into two tasks that corresponded with the two primary project objectives. The goal of the first task was to optimize the FHZ deliverables provided to the county after completion of the Fluvial Hazard Zone pilot mapping. This included examining and verifying the FHZ map data, particularly in relation to the regulatory floodplain, to identify properties and infrastructure at risk and develop useable map products. The county hired a consultant, Lynker Technologies, to assist with the bulk of the spatial analysis.

Originally, we were interested in using the Relative Elevation Model (REM) generated from the FHZ Program to depict "heat maps" of relative stream power. The idea was to better understand and represent the distribution of erosion risk across the Active Stream Corridor. However, the REM created during the Fluvial Hazard Zone mapping project was based on elevation data that predates much of the stream restoration and other recovery work completed after the 2013 floods. The best available LiDAR data (dated 2020) that we needed to complete a revised REM did not become available to us until May of 2022, near the end of the project. We decided that Lynker's expertise would be better focused on more general spatial analysis that could help the county understand the lands, buildings, and infrastructure at risk from fluvial hazards, particularly in comparison with the regulatory floodplain.

Task Two

The second task was to integrate the FHZ data and fluvial hazard mitigation guidance into the county's existing plans and practices and generate outreach materials that could help the public understand the significance of the FHZ in Boulder County. This involved detailed review of the existing Boulder County Comprehensive Plan, Boulder County Hazard Mitigation Plan, and Boulder County Land Use Code to determine how to incorporate fluvial hazards into the county's short and long-term planning. Floodplain Management Program staff also interviewed other staff in the Community Planning & Permitting Department as well as the Parks & Open Space Departments about possible pathways to integrate fluvial hazard mapping into development review and long-term acquisition prioritization.

Results

Spatial Analysis of the Boulder County FHZ

As described in the accompanying report from Lynker (Appendix A), the FHZ boundaries in Boulder County delineate a much broader zone of risk than the regulatory boundaries like the floodway and the 100-year floodplain. As a result, there are hundreds of homes in Boulder County that lie outside of regulatory flood boundaries but that are still at risk from fluvial hazards. Specifically, approximately 1/3 of the homes within the newly mapped FHZ are outside of boundaries that are currently regulated by Boulder County. Lynker's analysis also highlighted the degree to which Boulder County infrastructure may be vulnerable to fluvial hazards: more than 150 bridges and culverts, and nearly 20 miles of roads, lie in portions of the FHZ that are outside of the 100-year floodplain.

Lynker also reviewed post-flood substantial damage estimate (SDE) reports from the 2013 floods in the context of regulatory boundaries and the FHZ, to evaluate how observed damage from that event

related to these boundaries. This analysis demonstrated that several of the homes that were damaged in the 2013 flood were in the portion of the FHZ that lies outside of the floodway, 100-year floodplain, and other flood boundaries regulated by Boulder County. However, homes inside of regulatory boundaries were more likely to be damaged in 2013 than those in other parts of the FHZ: more than half of the properties with SDE reports were inside the floodway, and almost three quarters of the properties with SDE reports were inside the 100-year floodplain. In contrast, only 12% of the homes damaged in the 2013 flood were within the FHZ but outside of all regulatory boundaries (including the 500-year floodplain).

Lynker conducted a desktop-level QA/QC of the FHZ boundaries for Boulder County, comparing the FHZ to regulatory layers, erodibility data, and aerial imagery. This QA/QC process verified that the FHZ is more conservative and more widely encompassing of at-risk areas than the various regulatory layers across the entirety of Boulder County. The active stream channel of the FHZ loosely corresponds to areas of lower erodibility in the SSURGO soils index, though the alignment is not exact, and the avulsion hazard zones and geotechnical flags with this dataset appear to be sufficient for Boulder County, based on available aerial imagery. Despite limited time with access to the 2020 LiDAR dataset, Lynker compared the LiDAR datasets from 2013 and 2020 to locate areas within the FHZ that had experienced channel migration and sediment movement during that time period. Evidence of channel movement, scouring, and sedimentation are located throughout the entire FHZ area, further contributing to the idea that regulatory boundaries based on a channel's location at a specific time do not sufficiently capture long-term risk as the floodplain gradually morphs.

Integration with the Boulder County Multi-Hazard Mitigation Plan

The Boulder Office of Disaster Management, in collaboration with Boulder County and its municipalities, is in the process of revising the Boulder Multi-Hazard Mitigation Plan (MHMP). The MHMP consists of a core plan that discusses the various hazards faced by Boulder County and their history of occurrence, and an annex for each community that lists specific hazard mitigation efforts in place or planned.

Previous versions of the MHMP have not addressed fluvial hazards, either as a basic hazard in the core plan or as a mitigation effort listed in the Boulder County annex. As part of this project, we have recommended language to be included on the draft core plan revision that formally acknowledges fluvial hazards in riverine flooding. We have incorporated fluvial hazard zone data integration as a mitigation action listed in the Boulder County Annex that focuses on maintaining updated flood hazard studies and delineation maps. This additional language is included in Appendix B.

Integration with the Boulder County Comprehensive Plan

Land use decisions in Boulder County are guided by the Boulder County Comprehensive Plan (BCCP). While fluvial hazard zones are not currently integrated into land use guidelines or recommendations for site-specific study, there are components of the BCCP that could be updated to more explicitly acknowledge and manage risks in the FHZ. This section summarizes excerpts from the BCCP where fluvial hazards could be relevant, along with some recommendations for how the results from this project could be integrated into future BCCP updates.

1. Geology Element

The BCCP Geology Element includes the following definition of Fluvial Hazards: "Areas susceptible to fluvial hazards based on the area a stream has occupied in recent history, could potentially occupy, or could physically influence as it stores and transports sediment and debris during flood events." This closely aligns with the definition of Fluvial Hazards used in the FHZ protocol. However, unlike other geologic hazards defined the plan, the BCCP does not provide specific Land Use Guidelines for Fluvial Hazards.

At a minimum, the county should consider adding a map of the FHZ to the BCCP, either as part of the existing "Geologic Hazard and Constraint Areas" map or as a standalone map. An example of an FHZ map in the style and format of other Comprehensive Plan maps is included in Appendix C. Adopting the FHZ mapping into the BCCP would ensure that applicants who come to the county under a development review process receive FHZ maps for their property. Even if no requirements are associated with the FHZ, adopting the map allows applicants to have a conversation with county staff about fluvial hazards.

The county could also go a step further and develop more specific policies or land use guidelines for the FHZ. For example, the following policy applies to geologic hazards and constraints generally:

> ***GE 1.01 Development in Geologic Hazard and Constraint Areas.*** *…A geologic hazard study should be required and performed by a qualified Colorado Professional Geologist and a qualified professional (geotechnical) engineer for sites with the geologic conditions listed below, and development approval should be subject to the applicant completing the recommendations provided in the completed study.*
>
> • *Documented landslide, debris flow or rockfall deposit or event.*
> • *Landslide hazard susceptibility.*
> • *Debris flow hazard susceptibility.*
> • *Rockfall susceptibility.*
> • *Steeply Dipping Heaving Bedrock mapped extents within property boundaries.*
> • *Undermined Area mapped extents within or near property boundaries.*

The county could consider adding fluvial hazards to the list above, to ensure that some level of geologic hazard analysis be completed prior to new development within the FHZ. The CWCB's model ordinance for a hypothetical FHZ Overlay District includes a description of the type of study that could be required for development in the FHZ; specifically, an analysis of the sediment storage volume and fluid energy for 2-year through 500-year flood events. Projects that proposed to alter the sediment storage volume could be required to provide compensatory storage if grading or other activities (e.g. construction of buildings) reduce the sediment storage volume.

2. Natural Hazards Element

The goal of the Natural Hazards Element of the BCCP is to protect people and structures from natural hazards, including flooding, erosion, and debris flows, by limiting development in high-risk areas and

mitigating existing risks. While the Natural Hazards Element includes "Limits to Development in Floodplains" (Sec. NH 4.01), it does not consider the broader FHZ. The policies listed below relate to flooding and erosion hazards and are accompanied by recommendations for integrating fluvial hazards into this element.

> ***NH 1.02 Public Awareness of Risks.*** *Natural hazards potentially affecting the county should continue to be identified and made known to the public and public officials. The county should promote a high level of public awareness about the risks of these identified hazards which may impact people, property, and the environment…*

The county is planning to publicize the FHZ map layers and the online Story Map to promote awareness of fluvial hazards as described in policy NH 1.02 above. However, incorporating the FHZ into the BCCP more explicitly, either in the existing "Geologic Hazard and Constraint Areas" map associated with the Geology element or in a standalone map, would allow the county to use existing public processes to promote awareness of fluvial hazards among the public and public officials.

> ***NH 1.03 Land Use Activities.*** *The county should ensure to the extent possible that land use activities do not aggravate, accelerate, or increase the level of risk from natural hazards.*
> ***NH 1.03.01*** *Development activities should be designed to minimize alteration of the natural landform to the greatest extent possible, thus reducing slope instability and drainage problems.*
> ***NH 1.03.02*** *Areas (including any structures) around a proposed project should be protected from the potential adverse impacts caused by the project. These adverse impacts include, but are not limited to: a) disturbance of existing vegetation, which can lead to accelerated erosion and sedimentation; b) aggravation or acceleration of existing potential hazards (e.g., rockfall, flooding, sediment accumulation, expansive soils)*

> ***NH 3.02 Drainage and Erosion.*** *Drainage from development or any alterations to historic drainage patterns shall not increase erosion either on site or on adjacent properties.*

The policies above could be interpreted to already cover fluvial hazards to some extent. However, preserving vegetation, for example, is a mitigation strategy for on-site erosion issues. Erosion in the context of the FHZ is larger in scale and may require different mitigation strategies. The policies above could be modified to include fluvial hazards more explicitly by considering not just on-site sediment accumulation, but also downstream impacts of proposed development on erosion, sedimentation, and other fluvial hazards.

> ***NH 1.04 Risk Reduction*** *The level of risk from natural hazards should be reduced through positive county action such as guiding development away from areas prone to natural disturbances, mitigating existing development from hazards, and considering the impact on ability to provide emergency services.*

> ***NH 2.01 Development in Geologic Hazard Areas*** *Development in designated Geologic Hazard Areas (shown on the "Geologic Hazard & Constraint Areas" Map) should be discouraged. Development*

should only be allowed in these designated hazard areas when adequate mitigation or elimination of the potential hazards can be demonstrated.

As described above, we recommend incorporating the FHZ into the "Geologic Hazard and Constraint Areas" map. This would make it easier for the county to discourage development in areas at risk from erosion and sedimentation hazards within the FHZ. For example, Fluvial Hazard Zones would be included in the map packages provided to residents that apply for development review. The floodplain program could also include fluvial hazard language and advisories in its responses to development review referral (see next section). Although it is difficult to completely eliminate fluvial hazards, mitigation could include compensatory sediment storage areas or other recommendations from a fluvial hazard study.

NH 4.01 Limits to Development in Floodplains *The county should strongly discourage and strictly control land use development from locating in designated floodplains, as identified in the Boulder County Zoning Maps.*

The county should consider modifying this policy to reflect fluvial hazard zones more broadly, e.g., "…strictly control land use development from locating in designated floodplains, and consider ways to discourage development in parts of the fluvial hazard zone that lie outside of designated floodplains…"

NH 4.04 Acquiring and/or Relocating Existing Structures. *The county, either individually or in partnership with others, should examine alternatives for acquiring and/or relocating existing structures prone to flooding.*

This policy could be modified to include fluvial hazards as follows: "…existing structures prone to flooding or other fluvial hazards." When funded through federal grant programs through the National Flood Insurance Program (NFIP), buyout and relocation projects in the floodplain must meet a certain Benefit Cost Ratio. Considering fluvial hazards in addition to traditional floodplain boundaries and inundation depths will allow the county to consider a more complete picture of risk when evaluating buyouts. At a federal level, the National Flood Insurance Program should also consider ways to quantify fluvial hazard risks and include them in their Benefit Cost Toolkit.

NH 4.05 Pre-Disaster Flood Mitigation Plan. *The county should continue to develop and refine the countywide Pre-Disaster Flood Mitigation Plan.*

See Appendix B for recommendations related to the Multi-Hazard Mitigation Plan.

NH 4.06 Community Rating System. *The county will continue to participate and implement the Community Rating System program as part of the National Flood Insurance Program (NFIP).*

The Community Rating System (CRS) allows county residents to receive discounts on flood insurance policies purchased through the NFIP for county efforts that go above and beyond the minimum NFIP standards. The FHZ mapping and outreach will likely result in additional points for the county under CRS. The county encourages FEMA to consider additional fluvial hazards in Section 400 of the CRS.

3. Environmental Resources Element

The BCCP formalizes the county's commitment to preserving, conserving, and restoring the county's natural features, ecosystems, and landscapes. The BCCP recognizes the importance of wetlands and riparian areas specifically for their habitat and biodiversity value, and their functions as movement corridors for wildlife. The BCCP also incorporates official maps (Policy ER 3.01) of "Environmental Conservation Areas," including maps of Wetlands and Riparian Areas. The official Riparian Areas Map is a simple prescribed buffer around all perennial streams (100-feet). This buffer is not regulatory—in other words, there are no development standards or regulations that apply to land within the buffer. The buffer is used primarily as an indicator that riparian habitats may be present, and when reviewing nearby proposed development, additional field investigation is required to identify specific riparian areas that should be preserved.

As documented in Lynker's spatial analysis in Appendix 1, the FHZ is generally a more conservative depiction of flood hazards than the riparian buffer. However, riparian buffers are a complementary mapping effort and an important function associated with fluvial areas that should be preserved.

4. Sustainability Element

The BCCP also establishes the founding principles of the county's Transfer of Development Rights (TDR) program. One purpose for this program is to "avoid or reduce the fragmentation and disturbance of important ecological and environmental areas, including but not limited to significant plant and wildlife habitats, wetlands and riparian areas, and Environmental Conservation Areas." The TDR program allows owners of properties with high preservation value to transfer or sell their development rights to owners of properties that are more suitable for development. Land on which development rights are forfeited is then protected under a conservation easement. Transferring development rights is voluntary, and owners have a choice in deciding how their lands will be used. Residents may be required to purchase available development "credits" in order to build a home above a certain size. Because the FHZ is also associated with riparian and other environmentally valuable lands, the TDR program may be an option for some property owners within the FHZ.

Integration with Boulder County Development Review Procedures

To a large degree, the goals and policies set forth in the BCCP are executed in the Boulder County Land Use Code and its standards for development. The county reviews new development through one of several processes depending on the type and scope of development (e.g. Site Plan Review, Special Review, or Areas and Activities of State Interest Review per Colorado House Bill 1041). Reviews are meant to ensure that development will meet development standards. The county's development reviews already include criteria regarding the avoidance of natural hazards:

> *The proposed development shall avoid natural hazards, including those on the subject property and those originating off-site with a reasonable likelihood of affecting the subject property. Natural hazards include, without limitation, expansive soils or claystone, subsiding soils, soil creep areas, or questionable soils where the safe-sustaining power of the soils is in doubt; landslides, mudslides, mudfalls, debris fans, unstable slopes, and rockfalls; flash flooding corridors, alluvial fans, floodways, floodplains, and flood-prone areas; and avalanche corridors. Natural hazards may be identified in the*

Comprehensive Plan Geologic Hazard and Constraint Areas Map or through the Site Plan Review process using the best available information. Best available information includes, without limitation, updated topographic or geologic data, Colorado Geologic Survey landslide or earth/debris flow data, interim floodplain mapping data, and creek planning studies. Development within or affecting such natural hazards may be approved, subject to acceptable measures that will satisfactorily mitigate all significant hazard risk posed by the proposed development to the subject property and surrounding area, only if there is no way to avoid one or more hazards, no other sites on the subject property can be reasonably developed, or if reasonably necessary to avoid significant adverse impacts based upon other applicable Site Plan Review criteria (Land Use Code, Article 4-806.A.4).

Based on the ability to use "best available information," the Floodplain Management Program is already including the following language in its responses to development referrals when appropriate:

The proposed development is within a known fluvial hazard zone, which is the area a stream has occupied in recent history, could occupy, or could physically influence as it stores and transports water, sediment and debris. Parts of the property that are outside the regulatory FO District are still within the fluvial hazard zone and may be subject to excessive erosion, sedimentation, and/or wholesale changes in the location of the stream channel. The Floodplain Management Program strongly encourages the applicant to consider flood protection measures above and beyond the minimum requirements of the Land Use Code.

Providing this advisory language during development reviews is the first step towards utilizing FHZ mapping. Incorporating fluvial hazards into the BCCP will allow county staff to require more site-specific studies of fluvial hazards and make recommendations for (or require) mitigation of the hazards. The discussion with the public and public officials during the BCCP adoption process will guide the level of regulation for the FHZ. For example, the county could treat the FHZ as it does the regulatory floodplain by requiring FHZ Use Permits with specific mitigation measures, in accordance with the CWCB's model ordinance for the FHZ. Alternately, the county could treat fluvial hazards like other geological hazards in the Comprehensive Plan by requiring site-specific studies by a Professional Engineer and implementing mitigation measures on a case-by-case basis. The county could also decide to continue doing outreach around the FHZ, but not develop permitting requirements for development in the FHZ.

Currently, the Floodplain Management Program only reviews development applications when the subject parcel overlaps the regulatory floodplain. As a result, development could occur in the FHZ without ever having been referred to the Floodplain Management Program. This is yet another reason to incorporate fluvial hazards into the BCCP maps; it will promote awareness of fluvial hazards among applicants and county staff and allow for more seamless incorporation with existing review procedures.

Outreach

As part of this project, Community Planning & Permitting developed a Story Map to better communicate the types of hazards that exist within the FHZ, how these hazards are distinct from more general flood hazards, and convey a summary of some of the key findings from Lynker's technical report. The Story Map also links to an interactive map that illustrates the spatial extent of the FHZ within Boulder County.

This Story Map is available to the general public at https://arcg.is/1yu9Cm and will be linked on the main page of the county's floodplain program webpage. The Floodplain Management Program plans to use the Story Map to conduct additional "inreach" among county departments. Further outreach will be planned around any future updates to the BCCP or Land Use Code.

Conclusions and Discussion

The draft fluvial hazard zone maps that were created for Boulder County provide the Floodplain Management Program with new geospatial data highlighting areas that are potentially at risk from erosion and sedimentation hazards. The objectives of this water plan grant project were 1) to understand how these new data inform risk to buildings, roads and infrastructure in Boulder County so that adaptation actions can be prioritized; and 2) to develop an outreach strategy that can help communicate risks from fluvial hazards and inform adaptation strategies.

Our approach to understanding how the FHZ boundaries inform risk was to compare the FHZ delineations to more familiar flood risk boundaries in Boulder County, and to evaluate what these new boundaries imply in terms of additional risk to properties, infrastructure, and assets. To that end, we summarized aerial differences between the FHZ and regulatory floodplain boundaries; we quantified homes and assets within the FHZ relative to the 100-year floodplain, floodway, and other boundaries; and we compared actual damages to homes during the 2013 floods within each regulatory boundary. The results of this analysis are included in Lynker's final report (Appendix A). Our approach to risk communication and outreach was to prepare a public-facing ArcGIS StoryMap that informs Boulder County residents about the risks from fluvial hazards, the spatial extent of the FHZ in Boulder County, and how this boundary relates to other regulatory boundaries that may be more familiar to County residents.

As the project progressed, we made two minor changes to our initial work plan. First, we determined that maps of relative stream power, while easily developed using the relative elevation models provided to Boulder County, may not be a useful depiction of relative risk within the FHZ. This is because these highly dynamic river channels rapidly change course during large flood events, which quickly change channel geometry and redistribute erosional power across the FHZ. This dynamic behavior was further evidenced through a comparison of LiDAR-based digital elevation models from 2013 and 2020 that showed visible channel migration in Boulder County's major streams. Rather than using the initial channel geometry as a metric of relative risk, we instead used observational data on damages from the 2013 flood as a proxy for relative risk within the FHZ.

Our second change to the work plan was to use some of our available funds to complete a desktop-level QA/QC of the FHZ maps provided to CPP. This external QA/QC is recommended as part of the FHZ delineation protocol (Blazewicz et al., 2020), and Boulder County recognized the value of this extra level of analysis as it considers ways to incorporate FHZ boundaries into community planning and permitting. The results of this desktop-level QA/QC are summarized in Lynker's final report to Boulder County (Appendix A). Even with these two changes to the task 1 work plan, we did not fully spend down task 1.

We therefore moved some funds to task 2, allowing the county to engage Lynker's expertise in making recommendations for integrating the FHZ into the BCCP and other planning language.

Boulder County's land use planning and risk communication activities are summarized in the Boulder County Comprehensive Plan and the Boulder County Multi-Hazard Mitigation Plan (MHMP), respectively. Leveraging the analysis developed as part of this project, the county will explore updating both documents to explicitly include fluvial hazard zones into its planning activities. Integrating the findings of this FHZ study into those existing frameworks is a logical next step for the county because the BCCP documents the county's land use decisions and the MHMP identifies the hazards that threaten Boulder County's residents and infrastructure. Additionally, the county has processes for soliciting public participation when either of these documents is revised. Thus, integrating fluvial hazards into the BCCP and MHMP will ensure that the public is well-informed about how the FHZ affects personal risks, and why it is being folded into land use planning decisions.

Finally, the county encourages the CWCB, FEMA, and other communities to consider similar FHZ analysis efforts. The FHZ is a valuable hazard delineation that may be useful for comprehensive flood risk management and development planning around the country. The FHZ may also be useful when demonstrating the true benefits of mitigating flood risk. Comparing FHZ policies and programs across communities will ultimately result in more robust and well-informed land use decisions.

Actual Expense Budget

The Excel workbook submitted with this report includes an actual expense budget. The invoice for reimbursement is included as a separate PDF. Based on the changes to the work plan described above, $5,000 was moved from Task 1 to Task 2. This allowed some of the funds that were originally budgeted for the relative stream power analysis to instead by used to further flesh out recommendations for the BCCP and MHMP in Task 2.

We are requesting full reimbursement for the $30,000 grant funds. The county exceeded its proposed in-kind staff match ($4,940) with an actual in-kind match of $5,411.66. The county's cash match was slightly underutilized due to Lynker coming in under their total budget of $35,000; the actual cash match was $2,859 as opposed to a proposed $5,000.

Appendix A: Spatial Analysis of the Boulder County FHZ

See separate PDF.

Appendix B: FHZ Language for 2022 MHMP Base Plan and Annex

Language added to the Base Plan
Recommended Modifications in Red
Section 4.3.9 "Flood," Page 4-49

Floodplain Basics
The area adjacent to a channel is the floodplain. Regulatory floodplains are illustrated on inundation maps, which show areas of potential flooding and water depths. In its common usage, the floodplain most often refers to that area that is inundated by the 100-year flood, the flood that has a 1% chance in any given year of being equaled or exceeded. The 100-year flood is the federal minimum standard to which communities regulate their floodplains through the NFIP.

Floodplains and the potential for flooding can change over time, both naturally and artificially. Changes in land use and land surfaces alter or constrain drainage pathways, which can result in localized flooding problems both in and out of mapped floodplains. Floodplains also change through natural geomorphic processes: over time, stream channels may migrate laterally as they continually transport sediment and debris. This can change the extent of flooding that occurs during a 100-year event, and therefore floodplain inundation maps must be periodically updated to remain accurate.

Riverine or Overbank Flooding
This type of flooding is defined as when a watercourse exceeds its "bank-full" capacity and is usually the most common type of flood event. Riverine flooding generally occurs as a result of prolonged rainfall, or rainfall that is combined with soils or drainage systems that are already saturated or overloaded from previous rain events. The duration of riverine floods may vary from a few hours to several days. Factors that directly affect the amount of flood runoff include precipitation amount, intensity, and spatial and temporal distribution; the amount of soil moisture; seasonal variation in vegetation; snow depth; and the water resistance of the surface due to urbanization. The largest watersheds extend as far west as the Continental Divide and snowmelt in these watersheds dominates streamflow in late spring and early summer. Heavy rainfall on top of the snow pack can increase the rate of snowmelt and the extra runoff can produce significant flooding downstream. Other factors, such as debris blocking a waterway or channel, can further aggravate a flood event. In portions of Boulder County, development has altered the natural environment, changing and interrupting some of the natural drainageways. As a result, drainage systems can become overloaded more frequently.

The most serious overbank flooding occurs during flash floods that result from intense rainstorms or following a dam failure. The term "flash flood" describes localized floods of great peak flow and magnitude and short duration. In contrast to riverine flooding, this type of flood usually results from a heavy rainfall on a relatively small drainage area. Flash floods by definition occur very quickly and may occur with little or no warning. Flash flood risk can be greatly increased when drainages are cleared of foliage that normally absorbs and slows the rate of runoff.

During severe overbank floods, streams in Boulder County can migrate laterally through the processes of bank erosion and sediment deposition. These are natural processes in stream channels that are difficult to predict and may result in greater damage to a building than inundation alone. Streams can erode into buildings and undermine foundations, and they can fill lower levels with sediment and debris. They can also create blockages of debris that redirect floods towards buildings and infrastructure.

Language added to the Annex – Mitigation Actions

Mitigation Action/Project Title	Flood Hazard Studies and Flood Hazard Mapping
Hazard(s) Mitigated	Flooding, Landslide/Mud and Debris Flow/Rock Fall, Subsidence
Mitigation Goal Addressed	Goals 1, 2, and 5
Priority (High,Medium, Low)	Medium
Project Description, Issue/Background	In 2017 and 2018, Boulder County adopted new flood hazard maps covering the majority of the county's regulatory floodplain. However, flood hazards change as rivers evolve naturally and floodplains are developed. Maintaining current flood hazard maps is critical to mitigation planning, development decisions, and risk assessments. Boulder County has committed to partnering with FEMA, the Colorado Water Conservation Board, the Mile-High Flood District, and neighboring communities to ensure that county flood hazard maps remain accurate by supporting new hydraulic surveys, hydrologic studies, and map revisions. In addition to updates to the FEMA Flood Insurance Rate Maps (FIRMs), the county is also committed to incorporating additional flood hazard maps, such as those that target fluvial hazards (erosion, deposition, and debris) and pluvial flooding, into its planning and regulatory programs. Additional flood hazard data will be integrated as it becomes available.
Other Alternatives	None
Responsible Office/Agency and Partners	Boulder County Community Planning & Permitting
Action Status (ONLY FOR CONTINUING ACTIONS)	As of 2022, the county is working with FEMA to complete FEMA's adoption of 220 miles of re-mapped floodplain. The county is also actively integrating new Fluvial Hazard Zone data from the Colorado Water Conservation Board into its review of proposed development, flood hazard outreach/education, and mitigation project planning.
Schedule *(Estimated Timeline for Completion)*	Revisions and new map adoptions will be episodic and ongoing as floodplains change, new development occurs, and new hydrologic, hydraulic, and terrain data become available.
Cost Estimate	Cost depends on funding availability and revision needs, estimated average cost is $50,000 per map revision/incorporation.
Existing or Potential Funding	Potential funding sources include FEMA's Hazard Mitigation Grant Program (HMGP), FEMA's Building Resilient Infrastructure and Communities (BRIC), Community Development Block Grant-Disaster Recovery (CDBG-DR), Mile High Flood District, Colorado Water Conservation Board, and/or Boulder County General Funds.
Benefits (Avoided Losses)	Benefits include preventing future loss to life and property by accurately identifying the flood risk to existing and future development.

Appendix C: Draft Comprehensive Plan-Style Map

See separate PDF.

References

Blazewicz, M., Jagt, K., and Sholtes, J. 2020. “Colorado Fluvial Hazard Zone Delineation Protocol Version 1.0.” Colorado Water Conservation Board.

Boulder County. 2022. “Land Use Code.” https://www.bouldercounty.org/property-and-land/land-use/planning/land-use-code/

Boulder County. 2020. “The Boulder County Comprehensive Plan.” https://www.bouldercounty.org/property-and-land/land-use/planning/boulder-county-comprehensive-plan/

Colorado Water Conservation Board. 2020. “Fluvial Hazard Zone Overlay District Model Ordinance Version 1.0.” https://www.coloradofhz.com/resources