# Watershed-based Disaster Recovery in Colorado

*a report on*

Technical Assistance in a Disaster Recovery Setting

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*For the*

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# Executive Summary

The 2013 Colorado floods were the result of a cascade of natural disasters that devastated Colorado's Front Range from Colorado Springs at the south to Fort Collins at the north. The US Department of Housing and Urban Development's Community Development Block Grant-Disaster Relief program (CDBG-DR) awarded the State of Colorado over $320 million for relief from the 2013 floods as well as the 2012 Black Canyon, Royal Gorge, Waldo Canyon and High Park fires. The Resilience Planning and the Watershed Resilience Pilot Programs were specifically designed to promote resiliency through regional and cross-sector collaboration, engagement of the public at large, and to develop and implement plans and projects that reduced community risk, restored or enhanced the environment, promoted economic and community development, promoted the development of affordable housing, implemented fair housing practices and/or enhanced the quality of life. Central to the success of program planning was the early cross-agency partnership between the Department of Local Affairs (DOLA) and the Colorado Water Conservation Board (CWCB). A Technical Assistance Team (TA Team) was procured to provide State of Colorado program managers with technical insight into the latest river science and appropriate best management practices to achieve ambitious resiliency goals as prioritized by the communities in each watershed.

The TA Team took on many facets of the disaster recovery. Master planning, funded by the CWCB, and coalition building happened concurrently shortly after the flood in order to prioritize recovery needs as directed by the stakeholders who were most affected. The Team also advocated for a new baseline of holistic watershed management to improve resiliency and enhance the natural aquatic environment. They encouraged innovative technologies to stakeholders and consultants and fostered the utilization of ecosystem services to improve economic development solutions. They reviewed Requests for Proposals (RFPs), commented on design plans by consultants and oversaw construction. The Team promoted education and outreach programs to the general public and advised on monitoring plans that defined and measured success.

The TA Team was instrumental in developing required minimum guidelines and protocols for master planning and watershed recovery. In June of 2015, 21 months after the flood, the coalitions were organized, educated on holistic river management and CDBG-DR regulations and were ready to implement their first projects. Round 1 funding was designed for initial small demonstration projects. The organizations gained experience with project implementation and the community learned about the value of local stakeholder groups, the fiscal relevance of ecological rehabilitation, the importance of public/private partnerships, and techniques used to expand floodplain capacity and build resiliency into their waterways. Had these organizations existed prior to the flood, the timeline to recovery would have been substantially shortened. Organizing whole communities who then had to negotiate with well-established local governments with a coalition staff of two persons was overwhelming. Furthermore, these new coalitions were now adding on project development for new projects using Federal disaster recovery funds. The TA Team guided the coalitions to success and in the end all the projects in Round 1 were technically and administratively successful. Five years after their construction, these projects have met or exceeded their stated goals and criteria for success.

The beginning of 2016 saw both the coalitions and local government partners really begin to ramp up on their larger watershed resiliency priority projects with both planning and implementation projects as a part of Round 2 funding. While Round 1 was funded primarily with the CDBG-DR program from HUD, funding for stream and floodplain rehabilitation in Round 2 came from two primary sources. The State had allocated over $36 million to the

Watershed Resiliency Pilot Program, and, through the CWCB, the Emergency Watershed Protection (EWP) Program from the Natural Resources Conservation Service (NRCS) put an additional $50 million into these projects sponsored by the coalitions. The TA team and the coalitions were challenged by the coordination of competing agencies and regulations and at times struggled with varying compliance procedures but ultimately the cooperating agencies allowed these important projects to proceed and succeed. Despite logistical and compliance hurdles, the coalitions managed to contract with consultants to complete the final designs and construction for $70 million in projects in all the affected watersheds.

The Colorado Department of Local Affairs took a calculated risk in developing the Watershed Resiliency Program and supporting local citizen coalitions. Not all the coalitions qualified for the final Round 3 funding. A few Coalitions went inactive or disbanded for various reasons following the flood recovery process, which was anticipated for some coalitions, particularly those in less populated watersheds. However, most coalitions survived and continue to do the important work of holistic watershed management with multiple partners. Both active and inactive coalitions will be prepared and ready to engage in their local watersheds and stand by to help others develop the partnerships needed to work effectively together when the next catastrophe strikes.

Many lessons were learned through this pilot project but most importantly is the value in developing and funding collaborative, stakeholder-driven watershed coalitions for building consensus and trust throughout impacted communities. This program made those most affected by the disaster a part of the solution. The natural processes that govern the morphology of rivers is not bound by lines of ownership. The development of a holistic approach to watershed rehabilitation must include public/private partnerships and it is only with a coalition of interests that decision-makers can truly build resiliency into their streams and floodplains.

Another important lesson included the early use of technical advisors during the emergency management phase immediately following the disaster. A substantial amount of unnecessary damage was caused by bulldozers clearing channels to remove debris. Had the TA Team been activated earlier, they could have advised operators and managers in techniques available to achieve their goal of opening drainage ways while utilizing natural river processes and minimizing the subsequent rehabilitation of streams. Also, not all debris needs to be removed. Much of the large woody material that clogged the streams could have been used in the reconstruction of bank stabilization projects and aquatic habitat restoration.

Agency partnerships proved to be cost-effective strategies to maximize resiliency and efficiency. The Watershed Resiliency Pilot Program partnered effectively with several federal and state agencies. The managers at the State and local level collaborated with CWCB, DHSEM, FEMA, HUD and the NRCS, among others, to work through complicated regulations that at times conflicted with each other to produce solutions that met the intended goal of each program. CDOT developed joint projects with the Watershed Resiliency Pilot Program to reconstruct river corridors in conjunction with adjacent roadways saving millions of dollars in the process.

The Watershed Resiliency Program was a first-ever pilot program designed to change the paradigm of how flood management strategies are implemented. This program utilized a watershed approach to replace traditional “band-aid”, channel-constraining practices and replace them with the latest river science. Strong leadership is essential to build resiliency into floodplain management and it needs to come at all levels of disaster recovery. The TA team has demonstrated its ability to advise on cost-effective and innovative technical

solutions to build resiliency into the State's floodplains and river systems through advanced techniques. Many of the projects constructed during the recovery process can now be used as showcases for future projects. It is the hope that those techniques will now become the "new normal" in resilient watershed restoration.

## Introduction

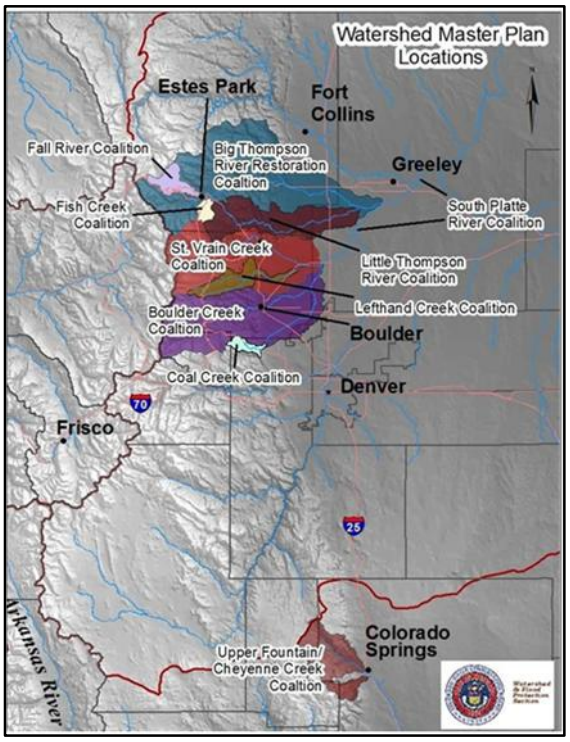
The 2013 floods were a series of natural disasters resulting in catastrophic flooding along Colorado's Front Range from Colorado Springs north to Fort Collins. Starting on September 11, 2013, a slow-moving cold front stalled over Colorado, clashing with warm humid monsoonal air from the south. The situation intensified and continued through September 15th with numerous flash floods, property destruction and loss of life. Ten deaths were reported, 11,000 people were evacuated, 1,500 homes were demolished, 19,000 homes were damaged, 30 State Highway bridges were destroyed and another 20 were seriously damaged.

The US Department of Housing and Urban Development's Community Development Block Grant-Disaster Relief program (CDBG-DR) awarded the State of Colorado over $320 million for relief from the 2013 floods as well as the 2012 Black Canyon, Royal Gorge, Waldo Canyon and High Park fires. Out of that allocation, approximately 10% went to the Watershed Resiliency Pilot Program and approximately 5% went to the Resilience Planning Program. The Resilience Planning and the Watershed Resilience Pilot Programs were specifically designed to promote resiliency through regional and cross-sector collaboration, engagement of the public at large, and to develop and implement plans and projects that reduce risk, restore or enhance the environment and wildlife habitat, promote economic and community development, promote development of affordable housing, implement fair housing practices and/or enhance quality of life. The Technical Assistance Team (TA Team) was organized and recruited to provide program managers technical insight into the latest river science and appropriate best management practices to achieve ambitious resiliency goals. In order to meet resiliency goals set forth in the Colorado Resiliency Framework, program managers needed to know if best management practices with respect to floodplain resiliency were being met. To build resiliency into rivers and floodplains during recovery from a disaster takes advanced and balanced skills in geomorphology, hydrology and engineering as well as the related community organization and communication skills that are indispensable to educating the public and organizing community leaders from various sectors of any watershed.

Resiliency for the Colorado Resiliency Framework was defined as: *The ability to rebound, positively adapt to, or thrive amidst changing conditions or challenges – including disasters and climate change - and maintain quality of life, healthy growth, durable systems, and conservation of resources for present and future generations.* The Technical Assistance Team (TA team) was developed to help ensure that for the Planning and Watershed programs, the implementation of multiple objectives essential to maximize safety and economic development and environmental enhancements as prioritized by the stakeholders in each watershed were are the forefront of all projects.

# The Role of the Technical Assistance Team

**Master Plans**




To meet the proposed resiliency standards, an initial TA effort funded by the CWCB involved developing the goals, objectives and guidelines for individual watershed master plans and simultaneously organize the formation of stakeholder-driven non-profit watershed coalitions to implement those master plans. During their formation, the CDBG-DR funding became available and the Watershed Program funded the necessary capacity for the coalitions to function. These watershed-based organizations were crucial to building trust and meeting the needs of the community while educating the public on how to rebuild from the disaster in a more resilient and better way. Disaster recovery often focuses on "getting things back the way they were" but that limited goal, by definition, precludes the opportunity for improvement. It takes more than just a few public meetings to convince landowners to abandon their individual property-based concepts of restoration and buy into a more holistic approach to stream and floodplain management. It takes neighbors talking to neighbors over time to build the trust necessary to recover in a more resilient manner and local watershed coalitions became the vehicles that built the consensus necessary to implement a wide range of collaborative projects.

**Coalition Building**

The value of local, non-profit watershed coalitions is often understated. Local governments often prioritize their recovery projects on public lands and infrastructure and do not, or cannot, work on private lands to develop a more holistic approach to watershed planning and rehabilitation. Building consensus and identifying priorities within a watershed are best left to the stakeholders most affected, and it is those stakeholders, with the ability to rally their neighbors, that create strong public/private partnerships with government. Those partnerships can create more cost-effective projects and improved efficiencies in the restoration effort. Raising funds in the private sector to match those from government is just one way non-profits can leverage recovery dollars and supplement project costs that are not available to federal or state programs. Organizing volunteers, operating in a relatively nimble manner, influencing local leaders, and combining local resources are other examples where coalitions foster the development of a more comprehensive approach to resiliency.

**Recruitment of Volunteers**

People from communities affected by disasters are often looking for opportunities to make a difference. The TA team recruited many altruistic individuals who were attending public meetings in search of information or opportunities to get involved. The TA team developed presentations around the creation of citizen-led coalitions and the impact that coalitions could have on holistic restoration. The team assisted in developing mission and vision statements, researched templates for by-laws, facilitated meetings for strategic planning and educated locals on innovative and resilient restoration practices. They helped identify

representative stakeholders from local government, landowners, industry, ditch companies, agriculture, and environmental and recreational interests to form Boards and committees for the organizational governance of coalitions. They continued to work with these new Boards to

advise them on the skills necessary for hiring watershed coordinators, design consultants and construction contractors as project development progressed.

If watershed organizations exist prior to disaster events they generally mobilize quickly and begin the recovery process collaboratively with local and state government. However, that was not the case in the 2013 flood event. The TA team worked to organize 9 out of the 10 watershed coalitions that eventually contracted with the State to implement projects. The one group that was already formed prior to the flood was able to contract with the State sooner, but even that group had to re-organize and revise their mission statement and their by-laws to expand their geographic boundaries. The others had to start from scratch which added many months to the project development process.

**Innovation**

The advocacy for holistic watershed management also extended to federal and state agencies and local governments. The team worked closely with the Federal Highway Administration, the Army Corps of Engineers, the Natural Resource Conservation Service, the US Forest Service, the Colorado Department of Transportation (CDOT), and numerous county permitting and public works departments. One example of a cost-saving partnership was the reconstruction of U.S. Highway 36 shortly after the flood to rehabilitate the stream channel in conjunction with the highway work. This partnership with CDOT afforded an opportunity to utilize highway reconstruction resources to design and construct stream channel enhancements adjacent to highway repairs and resulted in a cost savings of more than $1.1 million.

The TA team was essential to ensuring cost-effective projects utilizing innovative technologies to advance environmental improvements and increase floodplain capacity for future events. Concepts such as:

- channel complexity,
- floodplain storage,
- riparian restoration with diverse native species,
- installation of wood into the aquatic ecosystem,
- irrigation diversions constructed for safe recreational boating and upstream fish passage,
- utilization of complex sediment transport programs for reduced deposition at bridge crossings, and
- creative bank stabilization techniques

were all concepts that reduce cost and improve habitat that few engineers had experience with at the time.

The TA team also drafted model Requests for Proposals (RFPs) for both the State and the new Watershed Coalitions to encourage the design and implementation of these concepts. The team also reviewed proposals and advised Watershed Coordinators on the selection of consultants and contractors.

The TA team often found themselves working with designers and engineers to encourage innovation and cutting-edge technologies by expanding floodplain capacity and improving the aquatic habitat intended to meet resiliency goals. Moving both landowners and consultants out of their comfort zone to employ new concepts proved challenging for some but were embraced by others. However, the extra effort was well worth it. Instead of putting waterways "back the way they were", floodplain capacity and function was expanded and enhanced in most projects thereby reducing the potential future risk to life and property. The team encouraged the design of compound channels that allow for safe overbank flooding in high water events across well-vegetated floodplains thus reducing velocity and erosion and allowing for deposition away from housing and infrastructure. Building this shared knowledge in the consultant and contractor pool resulted in positive ripples through projects across the state and funded by different programs.

**Economic Development and Ecosystem Services**

Another important function of the TA team was encouraging and promoting environmental enhancements to aquatic and riparian ecosystems. Economic development and environmental improvements are often inextricably intertwined. Ecosystem services are the benefits to people from nature. These benefits include food, water purification, carbon sequestration, soil stabilization, aquatic and terrestrial habitat, recreation, cultural values, among others. The contribution of natural ecosystems to these benefits is often un-quantified and unmeasured, but the value of such benefits is gradually becoming more apparent as human populations grow and the demand for natural resources increases. Ecosystems can provide for many human needs now and into the future.

River corridors are increasingly becoming prime attractions for communities providing both passive and active recreation as well as the opportunity for reflection and solitude. Local economic development is beginning to center their efforts around access to natural areas as available. Healthy rivers provide ecosystem services that have traditionally been unrecognized in economic markets, government policies and land management practices. This is because most of these services are difficult to see and measure, and so their contribution to economic and social wellbeing was rarely considered when management decisions were made. Ecosystem services can lead to conservation actions that both protect biodiversity and provide benefits for people's well-being leading to sustainable use of natural capital, rather than overuse. A new discipline has grown, both in research and in application, with payment schemes, markets, and theoretical

debates about best practices and efficiency. Ecosystem services are slowly narrowing the gap between conservation and development.

A well-vegetated river floodplain not only provides capacity for floodwaters, reduces erosive velocities and provides for safe deposition of debris, but is also home for more species of birds than all other western vegetation combined. 80% of all vertebrate wildlife depend on riparian areas for at least half of their life. Access to river corridors provide recreational opportunities for fishing, swimming, boating, birdwatching, hiking, hunting and generally enhance the aesthetic value of communities. In addition to those services, a healthy floodplain acts like a sponge. In high water events the river and its floodplain absorb water and slowly release it during dry times to provide much needed water to agriculture and the environment as well as some level of increased safety for those along the corridor from the effects of high water events. Riparian corridors also act like a natural filter and clean pollutants from runoff to improve water quality.

**Promoting Current and Innovative River Science**


It is imperative that consultants know and understand the ecosystem services that healthy river corridors provide so their designs maximize the potential benefits in each project. Flood recovery projects are opportunities to increase resiliency and build back better and smarter and the TA team was in place to ensure maximum benefits for all stakeholders in a cost-effective manner. The team worked to educate coalitions and drafted RFP templates for watershed coordinators that recommended a well-rounded team of geomorphologists, engineers, biologists, hydrologists and ecologists to design projects that not only reduced risk to life and property but also maximized ecosystem services to help vitalize local economies. The team supported watershed coordinators and their Boards by reviewing design and construction proposals, answering technical questions and making recommendations.

**Irrigation Improvements**

Irrigation diversions are indispensable to agricultural production in the West and the 2013 flood impacted some of the most productive farmland in Colorado. Many in-stream diversion structures were completely washed away or severely damaged and inoperable. Immediately following the flood many ditch companies sought to rebuild as quickly as possible in order to get their farms back into production and there was little time to take advantage of program opportunities available to improve resiliency. Many were built back the way they were due to the complexity and long timelines of existing funding programs, but several were able to move forward with temporary measures while waiting to rebuild with new innovative technologies that reduced sedimentation into the ditch, provided for safer recreational boating and allowed for upstream fish migration. These projects are being used as examples of what can be done to simultaneously meet the needs of agriculture while addressing other important uses of the river. If low-interest loans that could be repaid with future program funds were made available early in the recovery process, more irrigation companies might have implemented new resilient technologies.

**Education & Outreach**
All the improvements within watersheds that were designed to increase resiliency, protect life and property, enhance environmental habitats and diversify local economies required a substantial amount of education and outreach. Many of these concepts are not common knowledge and at times were met with resistance from designers, engineers and landowners. Change does not come easily, therefore, the TA team provided resources, examples and engineering calculations to convince local leaders, agency managers, design consultants, landowners, watershed coordinators, coalition Boards and other stakeholders of the benefits of these types of improvements. Continued support of local watershed organizations can maximize the effectiveness of public outreach campaigns to reduce nonpoint source pollution, enhance ecosystem services and protect the waterways that community's treasure.

**Design Review**
The review of design plans early in the process was essential to maximizing the resiliency concepts identified by the TA team and detailed in project RFPs. At times, watershed coordinators or program managers at the State did not understand techniques described in a set of design plans or the necessity of certain modelling software or the reasonableness of a specific line item in the budget. The team was available to answer these questions and advise managers on cost effectiveness and appropriate technologies. Each design was reviewed at conceptual and preliminary stages and review comments were submitted back to the consultants through the watershed coordinators so contracted design teams could make plan revisions. Not only did this help educate coalition staff but it gave consultants direction on the implementation of innovative goals and objectives for resiliency in current and future projects. This Watershed Program not only revised the vision of a resilient stream system through the disaster recovery process but is helping change the paradigm of stream and floodplain management on all projects going forward beyond simply flood recovery efforts.

**Construction Oversight**
Construction oversight is an equally important part of the process. With new design concepts come new construction techniques and a whole new way of looking at construction management that includes an eye toward habitat enhancement. At times, project managers and equipment operators need to abandon long-held construction sequences and methods and learn new concepts such as protection of existing vegetation, surgical grading, implementation of channel complexities with large woody material, strategically-placed boulders, revegetation techniques that can survive varying water surface elevations, track-placed gravel riffles with native material, and other imaginative ideas that will reconstruct a channel and make it look like a stream without human impact. The ability to do field fit revisions that enhance the intent of the design is critical to stream and floodplain rehabilitation projects. The TA team worked with field engineers, construction managers and operators to improve safety, aquatic and riparian habitat enhancements and the development of new, lower impact construction methods.

**Defining Success**
Defining and measuring success in natural ecosystems can be a challenge. Stream channels are supposed to move to a certain degree and should naturally have some level of erosion and deposition, but too much movement and erosion can also be problematic. Many channel and floodplain assessment protocols are subjective and what is acceptable for one person may not be for another. Defining success at the onset of a project is important and determining the appropriate metrics to use to measure success can be tricky and costly. The TA team advised coalition coordinators on several tools available from simple survey techniques to strategic photo points to vegetative transects to qualitative assessments in order to provide assessment

options. Each project is different and may likely be served best by custom monitoring techniques.

There is generally no funding for adaptive management or post-construction monitoring, but ecosystem rehabilitation projects are dynamic and complicated and need tweaking and study to maximize success. If local coalitions are to continue developing collaborative projects in their watersheds, they need to learn which processes and protocols work best for their individual environments. Resiliency will improve with education. Future projects should contain line items in their budgets for monitoring and adaptive management. Making small adjustments to a stream project when potential problems arise, before it potentially unravels, will save money in the long run and will hone design and construction techniques to build additional efficiencies into future projects.

**Historic, Land Use & Climate Impacts**

Encroachment on drainageways from development pressure is not the only factor impacting the resiliency of floodplains. Climate change is also affecting local communities through more intense rainfall events, higher temperatures, and changing weather patterns that impact both natural ecosystems and the built environment. Changing precipitation patterns will affect both the quality and quantity of water resources at critical times of the year and there is a growing number of reasons why it benefits communities to take an integrated watershed approach to addressing these problems. One way communities can best address climate change is by capitalizing on the multiple benefits provided by intact, healthy watershed ecosystems and by promoting and implementing green infrastructure-based approaches to planning and land management. Green infrastructure includes watershed-scale networks of natural areas, such as forests, wetlands, and rivers, as well as built or engineered features that mimic or restore natural processes (e.g. rain gardens, green roofs, bioretention areas, etc.). By encouraging deliberate retention of these features, this approach capitalizes on existing natural resources and provides multiple benefits including improving water quality, reducing stormwater runoff, limiting habitat loss, enhancing quality of life for residents, and improving resiliency in a rapidly changing climate (e.g. flood protection). The utilization of natural ecosystem services also minimizes the need for constructed infrastructure and thus can lead to a reduction in the local tax burden.

The TA team helped accomplish the installation of many improved resiliency features in watersheds as well as the use of new “best practices” through analysis and education with State program managers, watershed coordinators, landowners, consultants, contractors, local government officials and agency land managers.

# Coalition Projects

**Round 1**

In many watersheds in Colorado, and the throughout the country, local coalitions exist to educate communities, assess risk, raise funds and develop projects designed to improve safety, protect infrastructure and enhance both the aquatic and terrestrial habitat of the watershed. Unfortunately, only one of the ten watershed coalitions organized after the 2013 flood existed prior to that event and the one that did exist, the Lefthand Watershed Oversight Group (LWOG), needed to substantially expand its geographic boundaries and its mission. Prior to the flood, LWOG existed primarily to support EPA efforts to rehabilitate acid mine drainage from the Captain Jack mine high in the watershed. For LWOG to manage flood recovery projects, they had to expand to encompass the entire Lefthand Creek watershed from the headwaters to the confluence with the St. Vrain River in Longmont. The other nine coalitions were not so lucky and had to start from scratch by building stakeholder Boards, defining their mission and vision statements, developing by-laws, filing articles of incorporation and hiring staff. In addition, each group was contracting with the State to hire staff and consultants to generate master plans designed to help organize and prioritize projects. The TA Team was instrumental in developing required minimum guidelines and protocols for master planning and watershed recovery. This took a considerable amount of time before the newly formed organizations were ready to begin planning and implementing their prioritized flood recovery projects.

In June of 2015, 21 months after the flood, the coalitions were organized, educated, and trained in CDBG-DR regulations and ready to implement their first projects. Round 1 projects were designed to be relatively small demonstration projects. With the help of the TA Team, the coalitions drafted Requests for Proposals (RFPs), interviewed and contracted with design/build teams, administered their grants, oversaw construction, and closed out their contracts. The learning curve was steep, but all the projects were constructed, administered and closed out successfully.

Not only did the organizations gain experience with project implementation, the community learned about the value of local stakeholder groups, the fiscal relevance of ecological rehabilitation, the importance of public/private partnerships and techniques used to expand floodplain capacity and build resiliency into their waterways. Holistic floodplain rehabilitation would not have happened if the funding went exclusively to local government as they were often overwhelmed with infrastructure projects and simply did not have the ability to work on private land. To complicate matters further, many landowners had a low level of trust with their local levels of government. Neighbors working with neighbors tended to build strong and effective collaborations, and for the most part, local governments appreciated the consensus-building efforts by the coalitions and the inclusion of a wide range of stakeholders into the process. Neither the government nor local stakeholders could effectively manage watershed recovery on their own - they needed each other in order to succeed.

Furthermore, the local governments within the 2013 flood recovery program did not have any experience or in-house expertise on the science behind stable stream systems. They relied primarily on transportation and stormwater engineers that focused mostly on hard-armoring bank stabilization projects. This, of course, has its place and is extremely important in the protection of infrastructure but it is only one piece of the watershed recovery puzzle. To build resiliency into waterways it is imperative to understand the hydrology, the ecology, and the morphology of these systems in order to maximize the economic benefits to both public and private stakeholders. Building coalitions created the partnerships necessary to comprehend all the interests involved in holistic watershed management.

These newly formed coalitions often felt overwhelmed. Organizing whole communities and negotiating with well-established local governments with a coalition staff of two people is hard enough, but now coalitions were adding on project development for new projects using Federal disaster recovery funds. The TA team worked with each coalition to develop project goals and objectives, identify necessary skill sets and deliverables from consultants, write RFPs, review proposals, develop ranking criteria, sit in on interviews and advise on qualified teams. The flood recovery team at DOLA had decided to make Round 1 a series of small demonstration projects and that decision proved to be a wise choice. Dozens of consultant and contractor teams submitted design/build proposals that inundated many of the coalition Boards and staff. The Round 1 process ended up weeding out many unqualified teams and gave the coalitions valuable experience with which to draw on during the larger Round 2 and 3 projects. The consultants eventually chosen to design and construct this first round of projects demonstrated a balance of professional disciplines that worked to generate a holistic approach to stream and floodplain rehabilitation.

The careful processes developed during this phase of the recovery set the stage for administration of the larger and more complex projects to come. Compliance with the rules and regulations of government programs can be cumbersome and complicated. Each of the coalitions worked diligently through these and coordinated closely among themselves to ensure proper compliance and construct projects on time and within budgets. Consequently, all the projects in Round 1 were technically and administratively successful. Five years after their construction, these projects have met or exceeded their stated goals and criteria for success.

**Round 2**

The beginning of 2016 saw both the coalitions and local government really begin to ramp up on their larger watershed resiliency priority projects. These included both planning and implementation projects. The Technical Assistance (TA) team was responsible for reviewing and commenting on proposals, RFP submittals, cost estimates for both design and construction, design reviews, construction oversight, review of as-built drawings and final reports.

While Round 1 was funded primarily with the CDBG-DR program from HUD, funding for stream and floodplain rehabilitation in Round 2 came from two primary sources. The state had allocated over $36 million to the Watershed Resiliency Pilot Program and the CWCB put an additional $50 million into these projects from the Emergency Watershed Protection (EWP) Program of the Natural Resources Conservation Service (NRCS). The EWP projects were often matched with 12.5% from CDBG-DR and another 12.5% from the CWCB. CDBG-DR also funded another $10 million for several projects outright as well. The TA team and the coalitions were challenged by the coordination of different competing agencies and regulations and at times struggled with varying compliance procedures but the ultimate cooperation from the agencies allowed these important projects to proceed and succeed. The goals of Colorado's Watershed Resiliency Pilot Program would have been severely curtailed had it not been for the constant coordination of the DOLA program manager, the coalitions, and the TA team.

*Planning Projects*- As part of the procurement process, the design phase was separated into a preliminary design (30% completion) and a final design (80% completion). This is common in the design and engineering field and is often done by the same consultant. However, the CDBG-DR program, funded by HUD, required that the consultant responsible for the 30% design was not eligible to bid on the 80% design. This would often result in additional design costs because data the first consultant found important to collect and analyze might be found

unnecessary by the consultant working on the next phase. There was also a trust and professional liability factor involved where one consultant would not accept data collected by others and would require the collection of their own data and the development of their own base maps before any Professional Engineer (PE) would certify plans for construction. This created a duplication of efforts that oftentimes could not be avoided due to professional liability protocols.

During this time period the CWCB became the lead agency in the administration of the EWP program while DOLA was managing the CDBG-DR program. Both programs were often funding and overseeing the same projects. Overlapping and differing compliance for two different program regulations became complicated and required additional coordination between State agencies and the coalitions. Furthermore, the CWCB decided it needed its own TA team and recruited members of the original TA team which split the original team in two. At that point coordination between the State agencies, the coalitions and the TA teams became even more challenging. The splitting of the team created confusion, decentralized the primary point of contact with the State and unnecessarily added to administrative costs.

Despite logistical and compliance hurdles, the coalitions managed to contract with consultants to complete the final designs for $70 million in construction projects in all the affected watersheds. In addition to the final designs for construction, the TA team reviewed and commented on dozens of other planning projects awarded to all the coalitions and affected counties totaling over $7 million. These included projects such as educational handbooks for stream crossings and citizen monitoring; hydrologic studies for local governments; watershed resiliency studies; hazard risk assessment and identification; fish passage studies; additional watershed master plans; ditch feasibility studies; and sediment transport analyses.

*Implementation Projects*- During the design phase of these projects the TA team reviewed and commented on all the designs and cross checked all cost estimates for reasonability. Once all comments were addressed and the plans were finalized, the coalitions drafted RFP's for construction. The TA team assisted in developing thorough scopes of work to minimize the potential for cost overruns. As bids came in the TA team was available for assisting coalitions in answering technical questions and was often asked to help review bids although all hiring decisions were made solely by the coalitions. The TA team also oversaw construction and verified completion in the field based upon the final approved construction plans and was responsible for reviewing as-builts and monitoring plans.

The same logistical and compliance hurdles that plagued the planning process was evident in the implementation process as well. Two different TA teams were often responsible for ensuring compliance to differing program regulations for the same projects. This created a confusing situation for the coalitions, the design engineers and the contractors and coordination was challenging. However, over $12 million worth of CDBG-DR projects were completed successfully and within budget in Round 2. Despite the unanticipated coordination problems, the combination of these two programs substantially improved the future resiliency of many Front Range watersheds and changed the dynamics of many projects to come. Watershed rehabilitation in Colorado took a giant step forward due to the precedent-setting success of the Watershed Resiliency Pilot Program.

**Round 3**

In this final round of funding for the Watershed Resiliency Program the coalitions really put their best projects forward including some labeled as their "legacy" projects. But not all coalitions qualified for funding in this round. In order to qualify there needed to be evidence

that the organization complied with all previous compliance regulations and was sustainable moving forward. The Little Thompson Watershed Coalition, the Estes Valley Watershed Coalition and the El Paso County Collaborative could not meet the requirements for varying reasons and consequently did not receive any funding. However, seven coalitions, three ditch companies and a county were awarded over $18 million in implementation grants and thirteen local governments and five coalitions were awarded over $4 million in planning grants.

The TA team assisted in the same way as previous rounds by advising on RFPs and specific scopes of work, reviewing proposals and cost estimates, commenting on design and construction plans, ensuring projects met resiliency and aquatic environmental program requirements, overseeing construction, reviewing as-built and monitoring plans and submitting final reports. The Counties and several large municipalities did not require much assistance from the TA team at this point. In those projects, the team generally ensured program guidelines were being followed and project costs were reasonable. The coalitions, ditch companies and small municipalities respected, and were appreciative of, the technical advice delivered throughout these Round 3 projects. In several instances, consultants and contractors had attempted to cut corners and deliver a product that was not in the best interest of the project or the sponsors. The TA team was able to explain the differences in quality or the anticipated performance of suggested plan changes and thus provide a more resilient project that met the goals and objectives of the program.

The EWP program only partially funded one project in Round 3 and subsequently much of the confusion in Round 2 regarding coordination and compliance was avoided.

## Survival of the Coalitions

Active, engaged and well-connected volunteers are the keys to successful Boards and a strong and active Board of Directors is essential to a successful watershed coalition. When it comes to citizen stakeholder coalitions, survival of the fittest is truly dependent on the Board. An organization can have the best qualified staff available but without a robust Board it will not realize its mission.

Most of the coalitions engaged in flood recovery came together quickly in the wake of a disaster to work with their neighbors on rehabilitating their local streams, floodplains and watersheds. Each coalition developed their own by-laws and governing structures to develop a legal entity in which to contract with the State for recovery grants. While it was generally the staff's job to manage the many restoration projects, it was the Board's responsibility for fundraising and managing the staff.

The evolution of these coalitions was all quite different and diverse and often depended upon the types of projects in their watersheds, the various agencies they would partner with and the cooperation of private property landowners along the streams. Some coalitions in urban areas developed partnerships with larger municipalities and other State agencies such as the Department of Transportation. Others in rural locations focused on mine waste or forest health or loss of agricultural lands and worked with other agencies to develop successful partnerships. Some coalitions were more tourism-focused while others had more residential interests. Each one was unique as was the makeup of each Board.

Developing volunteer Boards are extremely difficult. Many people want to do their part during a catastrophe but after the dust settles, oftentimes, they just want to go back to the lives they knew prior. It is important that the make-up of the Board reflects the interests of all stakeholders but if a particular watershed contains a more limited range of interests such as all residential or agriculture or all city-owned property it reduces the opportunity to build partnerships. This became an issue with some of the new coalitions in the Watershed Resiliency Program. Immediately following the flood, stakeholders bonded with like-minded interests and created coalitions in smaller watersheds that had limited opportunities for partnerships and intentionally kept it small for fear of being overwhelmed. It was a good strategic move for a new coalition with no non-profit experience but once the recovery dollars ended so did many of the options for long-term survival. If more of these watershed coalitions existed prior to the flood it may have avoided many of the pitfalls experienced during the recovery process.

Toward the end of the recovery program various organizational adaptations began to emerge. Several coalitions expanded their geographic boundaries to include other interests. Mountain-based organizations expanded to include streams on the plains. Others included different tributaries or expanded their interests to include agriculture or forest health. Several groups expanded their educational roles and developed citizen monitoring networks.

However, some simply did not make it and folded following the flood recovery process for different reasons. Two were small single-interest communities and could not generate enough interest in the community to fill empty Board seats. Another had a strong and diverse Board but conflicts within their Board alienated funders and staff. Two coalitions went inactive but still meet regularly and await new opportunities and funding to develop and implement new projects.

The time in between projects is critical to the sustainability of non-profit watershed

organizations. If fundraising for non-discretionary funds is not successful, groups often must let go of staff and start all over. Fundraising for more visible efforts like homeless shelters, food banks and health clinics are easier for the general public to relate to while communicating the urgency for watershed restoration is a harder sell. Those who understand the importance of the natural environment and give to that cause are generally a rare breed and it becomes a difficult task for volunteer Board members to step up and ask their neighbors and local businesses for donations. Therefore, it is important to develop and maintain funding programs such as the Cooperative Watershed Management Program from the Bureau of Reclamation and the rare program from private foundations that fund administrative costs for environmental projects. It is not surprising that watershed organizations struggle between projects. Although a few of the coalitions developed from the Watershed Resiliency Program have closed or become inactive, most are still thriving and when the next catastrophe strikes they will be prepared and ready to engage in their local watersheds and stand by to help others develop the partnerships needed to work effectively together.


The Colorado Department of Local Affairs and the Colorado Water Conservation Board took a calculated risk in developing the Watershed Resiliency Program. Instead of maintaining the status quo, they promoted a vision of cooperation between local governments and private stakeholders that funded dozens of high priority recovery projects that will serve as showcases for future stream and floodplain rehabilitation projects. And now, thanks to this program, the coalitions are now developing new monitoring, adaptive management, citizen education and pre-disaster planning programs in preparation for the next disaster. This program has changed the paradigm of disaster recovery forever in Colorado.

## Lessons Learned

*Balancing Needs* - The coalitions have been the backbone to the success of the Watershed Resiliency Program. One of the greatest lessons learned from this program has been the ability of the coalitions to build consensus among all stakeholders, both public and private. That is not an easy task. Local governments have their priorities to address the needs of public infrastructure but 90% of the damage identified by the 2013 flood occurred on private property. Recovering the important functions of an active floodplain required a holistic approach irrespective of property boundaries.

Oftentimes, throughout the recovery process, we found county and municipal authorities hesitant to participate in a comprehensive rehabilitation of an affected waterway because it is not in their purview to spend public dollars on private property. However, the natural processes that govern the morphology of rivers is not bound by lines of ownership. The actions taken on one property could have dramatic effects on upstream or downstream properties. Project limits to achieve resiliency should be based upon stream function and transitions from one river type to another. For example, rivers tend to have scouring zones and depositional zones and they change often depending on the valley type or meandering pattern. River projects need to be delineated by these natural boundaries and not by property boundaries.

Project success is dependent upon restoration within natural constraints and it is only with a coalition of interests that decision-makers can truly build resiliency into their streams and floodplains. Trust can be a rare commodity. Shortly after the flood, counties organized public meetings to inform their constituents of their proposed actions and obtain feedback. In many of those meetings the TA team heard from affected landowners that the meetings were a waste of time, and the county was going to do whatever it wanted regardless of their needs. There was not a high level of trust between property owners and their local governments. The coalition's greatest achievement was the ability to attract important decision-makers from all interest groups including private landowners, local government and water users, and plan balanced projects that met the needs of all involved. Once the coalitions were formed and funded it was surprising to observe the level of common ground obtained when coalition staff facilitated meetings toward a common goal. Coalitions served as the bridge to reconnect some level of trust in the watershed as seen in the implementation of dozens of successful projects.

*Flexible Funding, Timelines & Procurement Requirements* - Funding the coalitions provided the incentive for stakeholders to come to the table. Without the clear vision, goals and objectives of the program, the coalitions could not have succeeded, but the regulatory requirements of FEMA, HUD and the USDA were complicated and rigid federal requirements of one agency would at times contradict the requirements of another. Short timelines forced some important projects to be cancelled because of landowner concerns that probably could have been rectified with a little more time. Once a project was deobligated, the funds were required to go back to the federal program from which it came. If the transfer of funds from one project to another were allowed, many other important resiliency projects could have been implemented.

It is recommended that future disaster recovery programs encourage consistency in the design and construction teams and ensure that the CDBG-DR requirement that consultants contracted to develop 30% design drawings are not eligible to bid on final drawings is waived. The inconsistency of design consultants in the development of 30%, 60%, 80% or 100% drawings is exacerbated by the fact that different firms identify "percentage complete design drawings" in different ways. What one firm defines as a 30% design is not necessarily what another firm defines it as. The process could be simplified by using more general terms such as preliminary and final plans with an accompanying detailed scope of work for each.

The consistency recommendation for design consultants should also be extended to the TA team as well. When the EWP program emerged, the CWCB decided halfway through the recovery process that it wanted to select its own TA team to review and advise on the EWP program. While it is typical for funding programs, particularly managed by different agencies, to procure TA teams for those programs, one unified team or a pool of approved consultants used consistently across all state-managed funding programs may reduce potential confusion among coalitions and local governments in the future. The subsequent division of the original TA team between DOLA and the CWCB process caused confusion among State managers, the sponsoring coalitions, local governments, and the team itself. It was costly, unnecessary, and decentralized the primary point of contact with the State.

Once a coalition develops an effective working relationship with a consultant or a contractor through a proper procurement process, that coalition should be able to sole source additional projects to save time and money. Toward the end of the recovery process, coalitions struggled to find qualified consultants to bid on projects because new consultants determined the time and money necessary to submit a competitive proposal was not worth it. They assumed their chances of being awarded a contract was low. Therefore, coalitions would have to post their RFPs several times, delaying projects by many months or even having the project cancelled because of a lack of competitive proposals. It can also be more cost-effective to use contractors who are familiar with the goals and objectives of the client instead of beginning that relationship from scratch time and again. This is an example of a strong difference between holistic restoration projects completed in a dynamic natural system as compared to more traditional construction/infrastructure projects.

*I Just Want it Back the Way it Was* –Throughout much of the recovery process the TA Team and others often heard "I just want it back the way it was". That common refrain was tempered by the statement: "well, that didn't work out so well last time did it?" That sentiment is certainly understandable but would have eliminated many opportunities for improvement and resiliency. The goal of resiliency necessitates additional time for project planning with stakeholders to recognize every participant's agenda. Future disaster recovery needs to abide by the mantra "build back better".

One regrettable federal regulation was FEMA's policy of funding only what was needed to put it back the way it was. They did have an alternative program for improvements, but it took more time and was more complicated, so most applicants chose the simpler, more direct route to build back to the same level. Another contradictory policy was FEMA's reimbursement process that could prohibit the use of local variances, but local variances were sometimes necessary to remain compliant to FEMA floodplain regulations. The policy of "no rise" in the floodplain insurance maps severely hampered the implementation of creative solutions to ensure improved resiliency. The Watershed Resiliency Program was designed to rebuild smarter and encourage new technologies. Change comes hard with many people but over time enhanced and improved techniques will be become the new normal and these projects will become showcases for additional future projects.

*Emergency Management* – Shortly after the waters began to recede, emergency management teams began to clear stream channels, remove debris and construct temporary road access to impacted sites. However, in some cases, more damage was done to the river and floodplain by emergency equipment than was done by the flood. Bulldozers cut straight ditches down meandering river channels and every bit of large woody material was removed and shredded. If a team of river experts with disciplines in fluvial geomorphology, aquatic ecology and hydraulic engineering were available during the emergency management phase of the recovery, a substantial amount of money could have been saved in the restoration and reconstruction effort.

River designers and contractors spent a considerable amount of time and money reconstructing the horizontal alignment of the channel to replicate stream meanders, point bars, pools and riffles that were obliterated by emergency management bulldozers. If a river team were available during the process, they could have directed bulldozer operators in a manner that preliminarily enhanced natural channel processes while accomplishing the task of draining the floodplain. It would have made the future channel and floodplain rehabilitation easier and cheaper.

Similarly, contracts were awarded immediately following the flood to remove all debris from the floodplain. The channels were clogged with vehicles, destroyed homes, personal belongings and lots of trees. If a river team was consulted early in the process, they could have told authorities that large woody debris was valuable material in the reconstruction of the channel and floodplain. Instead, all large woody material was removed and shredded. Two years later designers and contractors were paying quite a bit of funds for trees with root wads still attached for both bank stabilization and aquatic habitat. If that resource was stockpiled for use later, a substantial amount of money could have been saved and the aquatic habitat of many streams could have been further enhanced.

*Road/River Nexus* – It is important that infrastructure and river designs teams are put together collaboratively with equal authority from the beginning of the project. River

designers and engineers should not be an afterthought. For instance, roadway engineers' expertise can often end with one-sided priorities of hard armoring and little attention paid to the aquatic and riparian environments. Simply armoring a roadway from an adjacent river could exacerbate damage elsewhere. The State should consider developing inter-agency stream teams that can cost-effectively balance conflicting priorities to maximize resiliency. In the Watershed Resiliency Program, the TA team often commented on potential environmental enhancements that were simply overlooked by engineers. Maximizing the health and function of the stream corridor also maximizes safety and community values.

The September 2013 flood event significantly damaged large portions of roadways throughout the flood-affected watersheds. Emergency roadway reconstruction activities were underway immediately following the flood, and a unique partnership quickly formed between federal and state highway agencies and state and private stream restoration experts that allowed river rehabilitation to occur concurrently as part of the permanent road reconstruction effort through the U.S. Hwy 36 corridor. This collaborative process proved to be a cost-effective and efficient way to protect the road from future river instability by rehabilitating the river utilizing highway reconstruction resources to design and construct stream channel enhancements. Similar partnerships where mutual benefit can occur are recommended and should be sought out. Not only did the partnership save more than $1.1 million in stream restoration costs throughout this corridor, but both the stream restoration project and the highway reconstruction project came away with lasting benefits. The collaborative process and joint projects resulted in a river/roadway corridor that is much improved and more resilient, from the standpoints of public safety, infrastructure protection, environmental and ecological health, and recreational opportunity.

The U.S. Hwy. 36 river restoration project was a success, due in large part to the support and encouragement of the CDOT and FHA leadership despite an accelerated timeframe, restricted equipment and material availability. As the project served as an excellent pilot project for testing process and partnerships, lessons learned throughout the process will be beneficial to future flood recovery efforts, and to other restoration projects that involve a shared roadway/river corridor. The following recommendations were developed as a result of that project and should be considered on all future road/river projects.

*Design the Road and River as a Single System* - In areas involving a shared roadway/river corridor, river planning and road planning should be approached and evaluated as a singular system, as opposed to being treated as two disparate planning projects. A sustainable road/river relationship goes beyond predicting 100-year water surface elevations and sizing riprap for roadway embankments. It starts with evaluating the locations of both the road and river to minimize the length of embankments that are subject to high shear stresses and sizes crossing structures that consider sediment and debris loads as well as flow capacity. The singular system design can also make great strides in reducing erosive energy in locations where the highway is vulnerable, as well as providing the grading and seeding to encourage vegetation that will serve ecologic functions as well as provide cohesive structure to the roadway embankments.

*Begin Collaboration in the Planning Stages of the Project* - Clear, early, and frequent communication between river restoration and roadway reconstruction specialists is paramount. For example, several project sites had the potential to significantly increase the width of the stream corridor and consequently decrease flood elevations and erosive forces on highway embankments. However, if a temporary roadway embankment was grouted prior to the participation of the stream team, reclaiming this filled area for floodplain expansion purposes becomes impossible. Furthermore, if the stream corridor was largely channelized during embankment construction, it would then have to be undone in the restoration process. This would not be necessary if roadway and river specialists can worked together from the onset of the project.

*Encourage Private Landowner Cooperation* - River processes do not start or stop on political boundaries and easement lines. Often, the most effective way to change or eliminate a vulnerability in a river corridor is to do work upstream, downstream, or on the opposite bank. In addition, in Colorado, many streambeds are owned by private citizens. Coordination with private landowners is critical to implementing a comprehensive and holistic project without the typical patchwork that frequently results from individual landowners working on their own. Cooperation with private landowners to conduct system-wide river improvements on both banks and upstream and downstream of property boundaries is necessary for this type of project. Most landowners are found be generally cooperative and allow restoration to take place almost seamlessly across ownership boundaries.

*Engage in a Concurrent Design and Construction Process* – Roadway/River projects underscore the cost-effectiveness of a collaborative design and construction project (rather than stand-alone separate projects). Executing the construction of the stream restoration work as a portion of the highway rebuild, rather than as a separate contract, likely saves agencies significant amounts of money. Projects are often able to capitalize on and utilize material generated elsewhere within the project corridor, drastically reducing construction costs. In addition, working within the structure of the concurrent road project means that mobilization and other project start-up and shut-down costs are minimized.

*Enlist Equipment Operators with River Construction Experience* - Working closely with well-trained equipment operators who have previous experience working in rivers and on river restoration projects could be beneficial. Efficiencies could be attained if equipment operators are versed in the language of river restoration design, necessitating fewer construction oversight hours by the design engineers. Furthermore, operators who have a background in environmental restoration are more likely to construct river-appropriate structures and those with the experience of building within the channel corridor are likely to have better focus on completing the critical design components.

*Preserve Fallen Trees and Large Wood* - Fallen trees with intact root balls, commonly referred to as large woody debris (LWD) or large wood, are a key component of stream stability and stream ecosystems. Decades of research has shown the removal of large wood, and debris jams created during flood events, have a destabilizing effect as the channel loses a significant amount of its ability to dissipate energy though non-destructive means. For a roadway embankment the presence and use of large wood may deflect and dissipate scouring flows providing an additional buffer to the roadway. Furthermore, the complex flow structures support nutrient loading that in-channel large wood provides. They provide profound benefits to the entire riparian ecosystem from macroinvertebrates to adult fishes to birds of prey and terrestrial mammals. Wherever and whenever possible, large wood should be stockpiled or left onsite for reuse in channel projects. It should not be burned or removed from the watershed. Chipping some wood debris into mulch for erosion control may, however, be worthwhile in some situations.

*Finish the Project with Intensive Revegetation* - Revegetation should be conducted or planned in conjunction with channel work. Native vegetation can have specific topographic and final grade requirements that are necessary for the plants to root and thrive. These considerations are best addressed in the design phase of the project. Immediate coordination with native vegetation experts such as the US Forest Service, the CWCB-supported Native Riparian Plant Propagation Program and/or volunteer groups such as Wildlands Restoration Volunteers and the Conservation Corps to improve native revegetation and reduce the need for post-construction weed control is recommended. Additionally, cooperation with these organizations could lead to cost-sharing or other creative financing agreements for revegetation efforts.

*Stockpile and Redistribute Topsoil* - In conjunction with revegetation, the preservation and perhaps even import of topsoil should be considered at the outset of a restoration project. Topsoil is critical to vegetation establishment, soil and sediment cohesion and a self-sustaining restoration project. Especially on projects where significant excavation into areas with layers of topsoil occurred, this limited resource should be stockpiled and graded into floodplain benches and bare channel banks to the extent possible throughout the project

area.

*Prioritize Trash Removal* - Trash removal should be considered a priority from the beginning of a flood recovery project. Significant amounts of trash not transferred off-site early can end up in danger of re-mobilizing during the next high runoff event and cause additional damage elsewhere.

*Create Opportunities for Public Access* – Oftentimes projects have the capacity to extend safe access to stream bank areas within road right-of-ways to the general public for fishing and other recreational activities. Exploration of the opportunity to partner with Colorado Parks and Wildlife for additional public benefit on all projects is recommended.

*Improve Roadway Embankments to Benefit the River* - The existing embankments built by CDOT to protect the road can be enhanced in many cases to dissipate river energy, slow water velocities and improve the aquatic habitat. Adding complexity to the stream bank can be accomplished by placing boulders in a more random pattern at the toe of the roadway embankment to slow flows along the outside bend of the stream. This benefits the river channel without compromising roadway protection. Naturalizing the embankments with the addition of willows and other native riparian vegetation would also provide benefits to the stream ecosystem.

*Highlight the Benefits to the Public and Public Perception* - A significant benefit to linking road and river work is the reduced inconvenience to nearby residents and drivers as they will experience only one set of traffic delays and road closures. Similarly, nearby residents are only subjected to the annoyances (dust, noise, etc.) of a single construction timeline which may reduce the despair and the "aren't they ever done?!" sentiment that arises as multiple projects are completed in a single and sometimes constrained geographic area. Additionally, designing and constructing the project as one indicates to the public that the government agencies are acting in cooperation and with the environment in mind as well as demonstrating that there is a drive to effectively complete the entire project and quickly move to the next area in need.

*Structural Encroachments into the Floodplain* – One of the most important tools for improving resiliency in the floodplain is FEMA's buy-out program. Rivers have been encroached upon for centuries and giving the river back some room to move and meander is critical to increasing safety and improving floodplain function. Moving at-risk structures out of the path of a potential flood eliminates that risk and improves safety for life and property in perpetuity.

However, property buy-out programs are slow and can take several years to implement. In the meantime, those potential buy-out properties cannot be used for anything related to floodplain rehabilitation. Holistic restoration projects often need multiple places to stage materials and access the river. These properties would be beneficial toward the overall rehabilitation of the river corridor, but FEMA currently does not allow staging on, or access through, potential buy-out properties. It is recommended that this policy be reviewed and revised.

The Coalitions could also play an important role in preventing future encroachments into the floodplain by lobbying local authorities to increase building setbacks from the river and adopting/enhancing relevant overlay zones. Throughout this flood recovery we have seen several missed opportunities for planning commissions to increase setbacks. While a tricky balance between private property rights and public safety, coalitions have been making efforts to educate officials and the public on the dangers of building too close to rivers and floodplains.

*Distribution of Planning and Implementation Resources* – During the recovery process a certain percentage of the overall project cost was allocated to planning. The EWP program required that design costs not exceed 10% of construction costs. Those design costs also included construction oversight. For million-dollar projects this could be reasonable, but on smaller projects that percentage share is too low. In many cases the effort and resources that go into design, engineering and oversight of stream restoration projects are similar despite the size of the project. For instance, 10% of a $15,000 project is not enough for design, engineering and oversight but could be more than is needed for a $5 million project. It is recommended that future projects use a sliding curve from 8% to 30% of construction costs depending on the size of the project. Furthermore, the TA team that was often used to determine cost reasonableness for construction work, could also be used to determine the appropriate cost percentage for design.

Another part of the planning process is developing standard specifications, pay items and bid tabs. These items are used as standard practice throughout most infrastructure projects. However, they have never been designed for stream restoration projects because there was never enough data to develop those standard specifications. Colorado Department of Transportation specifications were often used as a replacement during the flood recovery process, but design standards are much different for highway projects versus river and floodplain projects. River restoration efforts include geomorphic and ecological parameters that are not found in standard civil engineering specifications. Much more data on costs and specifications now exists and specific stream and floodplain specifications should now be developed for future projects.

Even if comprehensive standard specifications are developed for future stream and floodplain projects, there will always be a need for qualified professionals to oversee construction and have the flexibility to field-fit in order to implement best management practices. The

physical parameters that govern stream dynamics are extraordinarily complex and cannot be modeled or calculated like constructing a bridge or a building. An experienced professional needs the flexibility to move or adjust techniques or structures as they are installed in a stream system. For example, a revetment structure may need to be moved up or downstream a few feet based upon the observed flow in the channel during construction. Design engineers are also struggling to create complexities in new stream channels when grading equipment is computerized to construct exactly what is drawn on a set of plans. It is nearly impossible and very costly to design natural complexities into a set of plans. Field engineers and morphologists need the flexibility to add those features into their projects in order to work with natural river processes and not force the river into something that is not consistent with observed river processes.

Contractors also appreciate having a professional on-site that can make decisions regarding the placement or installation of structures, random boulders or large wood, pools and riffles and specific vegetation. Equipment operators do not want to make those decisions only to have a design engineer or hydrologist come back and move features to other locations. It is costly and frustrating to the contractors. Daily construction oversight leads to efficient construction practices, minimizes contractor errors and simplifies reviews of project invoices.

*Permitting* – During the recovery process several Federal and State agencies coordinated to develop a streamlined permitting process. The Army Corps of Engineers, US Fish & Wildlife Service, Colorado State Historic Preservation Office, Colorado Parks and Wildlife, and others worked collaboratively to develop a permitting process to expedite permitting and begin the reconstruction process. This could be an example for other agencies moving forward. However, FEMA floodplain regulations substantially restricted the development of safe alternatives to floodplain rehabilitation by requiring Conditional Letters of Map Revision (CLOMR) for any project that did not result in a "no-rise" of the regulatory flood insurance maps. This also included a lowering of the modeled floodplain map. A CLOMR could take a year or more to complete and potentially add hundreds of thousands of dollars to a project. This requirement severely limited creative designs for resiliency. Projects were eliminated or good alternatives not considered because timelines for project completion could not be met or costs exceeded budget limits.

In some instances, local permitting requirements increased costs and timelines unnecessarily. Some had to do with FEMA regulations, but others were simply too top-heavy and over-burdened applicants with so many requirements that it could take several months to a year to get through the process and obtain the proper permits. In the case of local authorities, this is an opportunity for local coalitions to develop a close working relationship with counties and municipalities to streamline permitting processes in a common-sense approach to recovery.

*Adaptive Management & Monitoring* – In most construction projects once a project is complete it is closed out. However, the complexities and uncertain dynamics of stream processes can require small repairs or revisions to projects that can prevent an unraveling of the project later. This does not necessarily indicate errors or flaws in the design or construction of the project. It is oftentimes an enhancement of the project and there should be a line-item in the budget for adaptive management and monitoring up to 5 years following initial construction. The placement of a small structure or boulder or large root wad in a strategic location could prevent a major channel failure later.

The definition of project success should be documented early in the design process. The implementation of small adaptive management techniques following the construction of a project could ensure project success over the long term. Also, good as-built drawings with

reliable and permanent coordinate locations are key to documenting that success. As-built drawings have sometimes been recorded without the necessary benchmarks to monitor the project for many years or decades afterwards. This monitoring is crucial to learning how to avoid future mistakes on a project-by-project basis and make for more resiliency and cost-effective projects in the future.

# Conclusion

The Watershed Resiliency Program in Colorado was a first-ever pilot program designed to change the paradigm of how flood management strategies are implemented. This program utilized a watershed approach to replace traditional "band-aid", channel-constraining practices and replace them with the latest river science that expands floodplain capacity, enhances aquatic habitat and improves the way we, as a society, interact with dynamic stream systems. The success of the program lied in its holistic vision of reach-scale funding and support for a stakeholder-driven recovery process and the program should be considered a permanent policy in future stream and floodplain rehabilitation.

Strong leadership is essential to build resiliency into floodplain management and it needs to come at all levels of disaster recovery. Most importantly, strong local watershed organizations are needed to build consensus and develop collaborative partnerships. They need the trust that can only come from local constituents and it was money well spent to support the establishment and administration of these local watershed organizations. Many of the successful floodplain rehabilitation projects implemented following the disastrous 2013 flood would not have been constructed had it not been for the hard work of these coalitions. They built the partnerships, educated local landowners, promoted innovative solutions, administered the funds and ensured strict compliance to program regulations. The Watershed Resiliency Program is a proven success due to the perseverance and tenacity of this new group of empowered local leaders.

The management of State and Federal disaster relief funds needs to be administered by one centralized state agency. The Colorado Department of Local Affairs (DOLA) is an agency that focuses on strengthening Colorado's local communities through local governments. It would be in the agency's best interest to expand support to local communities through collaborative local watershed organizations and manage the distribution of resources through cooperative coalitions. DOLA also has the experience and leadership to build cooperative partnerships across other state agencies such as the Colorado Water Conservation Board and the Colorado Department of Transportation as well as federal disaster relief agencies. The State should use whatever influence it has to recommend policy changes at HUD, FEMA and the NRCS to coordinate their individual relief programs and streamline program administration to the States.

The TA team has demonstrated its ability to advise DOLA, the CWCB and the Coalitions on cost-effective and innovative technical solutions to build resiliency into the State's floodplains through advanced techniques. The TA team was built with the professional disciplines needed to understand the complexity of stream and floodplain dynamics and used that expertise to advise agencies and stakeholders following the flood. The team oversaw the development of project proposals, design plans, construction and technical program compliance and reported on potential fraud, waste and abuse. Recommendations made by the team to incorporate the current best practices of river science influenced consultants and contractors hired by the coalitions to research and design innovative solutions that produced successful legacy projects on the ground in Colorado. Many of the projects constructed during the recovery process can now be used as showcases for future projects. It is the hope of the TA team that those techniques will now become the "new normal" in resilient watershed restoration.