Stream Habitat Investigations and Assistance

Federal Aid Project F-161-R23

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Federal Aid in Fish and Wildlife Restoration

Performance Report

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Aquatic Research Section

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The results of the research investigations contained in this report represent work of the authors and may or may not have been implemented as Colorado Parks & Wildlife policy by the Director or the Wildlife Commission.

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PERFORMANCE REPORT

State: Colorado

Project Number: F-161-R-23

Project Title: Stream Habitat Investigations and Assistance

Period Covered: July 1, 2016 through June 30, 2017

Principal Investigators: Matt C. Kondratieff and Eric E. Richer

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Project Objectives:

Job 1: Stream Restoration and Habitat Enhancement Studies

Need

Rivers and streams in Colorado have experienced substantial anthropogenic changes over the past 200 years. These changes were largely due to historic land-use activities and water development, such as beaver trapping, placer and gravel mining, flow regulation, timber harvest and tie drives, and construction of roads and railroads (Wohl, 2011). Many streams have been channelized in an attempt to convey floods, accommodate roads and railways, protect infrastructure, and maximize crop production. Grazing of livestock in riparian areas has also led to accelerated bank erosion, loss of riparian vegetation, and impaired aquatic habitat. These impacts have resulted in degradation of aquatic habitat and loss of stream functions from the watershed to reach scale. Fortunately, stream restoration efforts show promise as a means to support species recovery, improve water quality, and create new areas for wildlife habitat and recreational activities (Bernhardt et al., 2005). However, additional research on restoration methods and outcomes is needed to understand which techniques are most effective and sustainable.

Objectives

1. Survey and quantify salmonid populations at three project sites by June 30, 2017.
2. Survey salmonid habitat at three project sites by June 30, 2017.

Approach

Action #1:

- Level 1 Action Category: Data Collection and Analysis
- Level 2 Action Strategy: Research, survey or monitoring – fish and wildlife populations
- Level 3 Action Activities: Abundance determination; Age, size, and sex structure

Utilize Before-After Control-Treatment (BACT) study designs to monitor and evaluate stream restoration and habitat enhancement projects. During summer and fall months, we will conduct electrofishing sampling to determine salmonid biomass and individual fish lengths and weights in control and treatment sites. Fisheries data will be collected from select pre- and post-treatment stream reaches with assistance from aquatic biologists and researchers. Project sites include the (1) Yampa River below Stagecoach Reservoir, (2) Twin Tunnels on Clear Creek, (3) Upper Arkansas River, (4) South Platte River, and (5) Gunnison SWA on the Gunnison River.

Action #1 Accomplishments:

Fish inventory surveys were conducted at all five of the sites listed above, including the Yampa River, Clear Creek, Upper Arkansas River, South Platte River, and Gunnison River. Electrofishing sampling was conducted during summer and fall months in cooperation with CPW biologists to determine salmonid biomass, densities, and individual fish lengths and weights in control and treatment sites.

Yampa River
With some of the highest trout densities and biomass anywhere in Colorado, the Yampa River downstream of Stagecoach Reservoir is one of the most popular tailwater trout fishing destinations in the United States. Bank failure due to trampling from angler use, loss of stabilizing vegetation, and non-functional, in-channel boulder check dam features were the primary causes of habitat degradation and loss of trout productivity over time. Limiting factors to trout habitat included spawning habitat (exceedingly shallow depths or high concentrations of fine sediment), cover for adults (few undercut banks, deep pools, over-hanging bank vegetation, and large wood), and limited in-channel habitat complexity (in-channel structure to create resting areas and increase habitat complexity). Many of these limiting factors were addressed by a 0.25-mile habitat enhancement project that was completed in 2013. Target species for habitat enhancement include rainbow trout (*Oncorhynchus mykiss*) and brown trout (*Salmo trutta*).

Fish sampling was conducted for 14 years prior to habitat enhancement, providing a robust baseline dataset for post-project comparison. The second year of post-construction fish sampling was conducted in the fall of 2016 as part of a five-year monitoring study. Monitoring data will be used to evaluate fish population estimates, length-frequency distributions, and species composition in response to habitat enhancement activities. Since this is a unique tailwater reach, no suitable control site was located for comparison purposes. Therefore, habitat and fisheries response will be monitored as a before-after comparison only. This project will also be used as part of a larger research effort that will begin in the fall of 2017 to determine the relative contribution of habitat enhancement, fish stocking, and manipulation of competitive brown trout populations with the goal of re-establishing a wild rainbow trout fishery in the larger channel reach.

Clear Creek
Physical habitat characteristics of Clear Creek near Idaho Springs, Colorado, have been highly modified from historic conditions. The stream is generally confined by a major Interstate highway (I-70) on one side and a historic railway grade on the other. As most of Clear Creek has been channelized and armored with riprap to accommodate infrastructure, there are very few

locations with functional floodplains. The Twin Tunnels construction project was initiated by the Colorado Department of Transportation (CDOT). Once construction of the new tunnels was completed, a temporary frontage road was removed, providing a unique opportunity for riparian restoration within the I-70 corridor. The 0.4-mile riparian restoration and in-stream habitat project was completed in April 2015. Project goals were focused enhancing habitat for brown trout, improving conditions and access for anglers, and restoring natural processes. Specific objectives included: removing armored riprap, improving floodplain connectivity by converting the existing two-stage channelized river to a nested, four-stage channel, establishing riparian vegetation, enhancing in-channel habitat features (e.g., spawning gravel substrate within enhanced glides), and excavating deep lateral scour pools. Pre-construction data for fish populations were collected during the fall of 2012, 2013, and 2014 at two locations within the project reach. This established three years of baseline data prior to construction activities. The second year of post-construction fish monitoring was conducted in the fall of 2016. Fish population estimates, length-frequency distribution, and species composition will be monitoring for a total of five years to evaluate project effectiveness.

Arkansas River

The Upper Arkansas River Habitat Restoration Project near Leadville, Colorado, was implemented in 2013-2014 to address degraded fish habitat. Historic mining activities severely degraded water quality within the upper watershed and limited trout population abundance and growth rates in the Upper Arkansas River. As water quality treatment measures have been implemented, fish populations have recovered to a degree. Fisheries biologists have determined the next steps in recovering trout populations will come from addressing fish habitat limitations. Six fish monitoring sites (including three untreated, control sites) were established within the project reach to measure the effectiveness of habitat restoration. This project is unique in that some fish sampling sites have more than 16 years of baseline data collected prior to project implementation. These data provide baseline information for comparison with post-construction monitoring. Post-construction fish sampling was conducted immediately after the conclusion of project construction in 2014 and was continued in both 2015 and 2016. Fish population estimates, length-frequency distributions, and species composition will continue for a total of five years to evaluate project effectiveness. Preliminary results from fish population monitoring are presented in Richer et al. (2017).

South Platte River

Different “approaches” for trout-habitat enhancement (i.e., boulder vs. large-wood treatments) are being evaluated with a long-term BACT study on the South Platte River and Middle Fork South Platte River in South Park, Colorado. Four long-term monitoring sites include an upstream reference reach site (Tomahawk SWA), toe-wood and large wood-dominated treatment site (Badger Basin SWA), boulder-dominated treatment site (Badger Basin SWA), and a downstream impaired control site (Badger Basin SWA). Data have been collected at the boulder-treated and downstream control since 1990. All four of the long-term monitoring sites were sampled during the fall of 2016. Fish population estimates, length-frequency distribution, and species composition are being monitored to evaluate the long-term (20+ years) effectiveness of different approaches to fish habitat enhancement.

Gunnison River
Construction activities for the 2.5-mile Gunnison River and Riparian Rehabilitation Project on the Gunnison River SWA are scheduled to begin in the fall of 2017. Primary goals of this project include enhancing fish habitat by treating eroding banks, adding instream structures, and replacing temporary, push-up diversion dams with semi-permanent, boulder structures. Fish population data were collected for two separate stream reaches (control and treatment) using raft electrofishing and mark/recapture techniques during the summers of 2013, 2015, and 2016 to establish baseline fisheries data. The Almont site was used for the control reach and the Van Tuyl site will serve as the treatment reach. Data collected included fish population estimates, fish size by relative abundance, and fish species composition. Fish biomass and density estimates will provide baseline data for comparison to post-construction monitoring. Post-construction monitoring of fish populations will continue for a minimum of five years following project completion.

Action #2:

- Level 1 Action Category: Data Collection and Analysis
- Level 2 Action Strategy: Research, survey or monitoring – habitat
- Level 3 Action Activities: Baseline inventory; Monitoring

Topographic and sediment surveys will be used to evaluate changes in longitudinal profile, cross-sections, sediment, and habitat suitability. BACT studies will be conducted at appropriate site locations to evaluate changes in channel morphology following habitat treatments. For select sites, an Acoustic Doppler Current Profiler (ADCP) will be use to evaluate hydraulic conditions and habitat suitability. Project sites include (1) Wason and LaGarita Ranches on the Rio Grande River, (2) Twin Tunnels on Clear Creek, (3) Upper Arkansas River, (4) Charlie Meyers SWA on the South Platte River, and (5) Gunnison SWA on the Gunnison River.

Action #2 Accomplishments:

Topographic and sediment surveys were successfully conducted at three of the sites listed above: Clear Creek, Upper Arkansas River, and South Platte River. Surveys for the Wason and LaGarita Ranches on the Rio Grande River were completed during the previous reporting period, and data analysis for that project in ongoing. Survey data for the Gunnison SWA on the Gunnison River were also collected during previous reporting periods, but were used to develop final project designs during this reporting period.

Rio Grande River
Topographic and bathymetric surveys were conducted at the Wason and LaGarita Ranches on the Rio Grande River during the fall of 2015. Survey data were used to configure and calibrate HEC-RAS models to evaluate habitat characteristics (e.g., width, depth, velocity, and slope) across a range of flows. Data analysis and reporting for this project is ongoing.

Clear Creek
Topographic and sediment surveys for the 0.4-mile Twin Tunnels habitat project on Clear Creek were successfully completed during October 2016. Survey data are being used to produce as-

built drawings and a final report for the project. The as-built survey layout is shown in Appendix A, and the final as-built report should be completed during next reporting cycle.

Arkansas River

Annual longitudinal and cross-section surveys were completed for the Upper Arkansas River Habitat Restoration Project during the fall of 2016. Topographic and sediment surveys were also conducted at fish monitoring sites to support 2D habitat modeling. The total reach length for the project is approximately five river miles. Preliminary monitoring results, along with as-built drawings, were synthesized into a monitoring report that was published in March 2016 (Richer et al. 2017). Results from 2D habitat modeling were presented at the CO/WY/UT American Fisheries Society (AFS) meeting (Gates et al. 2017) are being synthesized into a publication that will be submitted for peer-review in 2017 (Gates et al. *In preparation).*

Gunnison River

Topographic surveys were completed for the 2.5-mile Gunnison River and Riparian Rehabilitation Project on the Gunnison River SWA during previous reporting cycles. Preliminary designs and floodplain analyses were also completed during the previous reporting cycle. During this reporting period, survey data were used to finalize the restoration design for the project and a Request for Proposals (RFP) was issued by the City of Gunnison in June 2017. The project will be implemented in two phases, with the first phase of construction currently scheduled for the fall of 2017.

South Platte River

As-built surveys for the 1.2-mile Charlie Meyers SWA habitat enhancement project were completed during August 2016. Survey data are being used to produce as-built drawings and 1D hydraulic models to support before-after habitat evaluation. The as-built survey layout is shown in Appendix A. The final as-built report should be completed during the next reporting cycle.

Expected Results and Benefits

Research findings will elucidate how stream restoration and habitat treatments improve fishery resources, as well as channel form and function. Study results will help refine techniques and maximize the benefit of habitat restoration on stream functions and rainbow trout (*Oncorhynchus mykiss*) and brown trout (*Salmo trutta*) fisheries. Results from multiple habitat-improvement projects will be synthesized to provide guidance for future restoration projects as part of a multi-year analysis.

References

Bernhardt, E.S., M.A. Palmer, J.D. Allan, G. Alexander, K. Barnas, S. Brooks, J. Carr, S. Clayton, C. Dahm, J. Follstad-Shah, D. Galat, S. Gloss, P. Goodwin, D. Hart, B. Hassett, R. Jenkinson, S.Katz, G.M. Kondolf, P.S. Lake, R. Lave, J. L.Meyer, T.K. O'Donnell, L. Pagano, B. Powell, E. Sudduth. 2005. Synthesizing US River Restoration Efforts. Science 308: 636-637.

Gates, E.A., E.E Richer, A.T. Herdrich, and M.C. Kondratieff. 2017. Evaluating the impact of stream restoration on brown trout habitat and available feeding positions in the Upper Arkansas River, CO. 2017 Joint Meeting of Utah and Colorado/Wyoming Chapters of the American Fisheries Society. Grand Junction, Colorado. February 23, 2017.

Gates, E.A., E.E Richer, A.T. Herdrich, and M.C. Kondratieff. *In preparation.* Utilizing two-dimensional modeling to evaluate the effectiveness of stream restoration on brown trout (*Salmo trutta*) habitat and foraging positions in the Upper Arkansas River, Colorado.

Richer, E.E., E.A. Gates, A.T. Herdrich, and M.C. Kondratieff. 2017. Upper Arkansas River habitat restoration project: 2013-2015 Monitoring Report. Colorado Parks and Wildlife Technical Publication 49.

Wohl, E. 2011. Seeing the forest for the trees: wood in stream restoration in the Colorado Front Range, United States. Pages 339–418 in Simon A., S.J. Bennett, J.M. Castro, eds. *Stream Restoration in Dynamic Fluvial Systems: Scientific Approaches, Analyses, and Tools*. American Geophysical Union.

Job 2: Fish Passage Studies

Need

Upstream migration is a vital component of the salmonid life cycle. Trout are known to migrate upstream to find ideal spawning habitat and then move back downstream to over-winter in warmer, lower-velocity, and more productive waters. Connectivity between spawning, rearing, and adult habitats, as well as refuge from environmental extremes such low or high flows, is an essential component of a trout fishery. Instream obstacles, such as waterfalls, culverts, and water-diversion structures, can have anthropogenic impacts on fisheries by fragmenting migratory ranges. Therefore, it is important that fisheries managers identify and evaluate the impact of instream structures on fish populations.

Objectives

1. Monitor hydraulic conditions and fish movement for one diversion structure fishway by June 30, 2017.
2. Provide guidance and technical assistance for two fish passage feasibility studies by June 30, 2017.

Approach

Action #1:

- Level 1 Action Category: Data Collection and Analysis
- Level 2 Action Strategy: Research, survey or monitoring – fish and wildlife populations
- Level 3 Action Activities: Movement

The Cache la Poudre River is fragmented by numerous water diversion structures that inhibit fish migration. In 2016, a new fish passage structure was implemented at the Fossil Creek Reservoir Inlet Diversion (FCRID) on the Cache la Poudre River. This new fishway will be evaluated to inform fish passage design at other diversion structures within the Colorado Front Range. Water depth and velocity within the fishway will be measured to evaluate effectiveness of the fishway across a range of stream flows. Fish passage success will be directly evaluated by marking and releasing rainbow trout (*Oncorhynchus mykiss*), brown trout (*Salmo trutta*), and various forage species downstream of the structure and monitoring upstream movement. Monitoring data will be used to determine if the FCRID fishway is meeting fish passage criteria and inform future fishway design.

Action #1 Accomplishments:

Construction a rock-ramp fishway at the Fossil Creek Reservoir Inlet Diversion (FCRID) on the Cache la Poudre River was completed in February 2016. Evaluation of the fishway was conducted throughout 2016 by monitoring hydraulic conditions and rock-ramp utilization by various fishes. Hydraulic conditions within the fishway were evaluated by measuring water depth and velocity across a range of stream flows. Fish passage success was evaluated by PIT-tagging a variety of fish species, including rainbow trout and brown trout, and releasing them into an enclosure downstream of the fishway entrance (Figure 1). Successful passage was monitored with RFID antennae placed at the entrance and exit of the fishway. The enclosure was removed after a few days, but antennae were left in place to monitor utilization of the fishway under more natural conditions.

Figure 1. Picture of the rock-ramp fishway at the Fossil Creek Reservoir Inlet Diversion (FCRID) showing the location of PIT-tag antennae and the downstream enclosure.

Preliminary results were presented at the CO/WY/UT AFS meeting by Krone et al. (2017) are being synthesized into a final report that will be submitted to project stakeholders in 2017 (Richer et al. *In preparation).* Results indicate that the fishway is meeting hydraulic design criteria for passage of trout and native forage species. All species that survived tagging and placement in the enclosure exhibited successful passage through the fishway by at least one individual, including brassy minnow (*Hybognathus hankinsoni*), brown trout, creek chub (*Semotilus atromaculatus*), green sunfish (*Lepomis cyanellus*), largemouth bass (*Micropterus salmoides*), longnose dace (*Rhinichthys cataractae*), longnose sucker (*Catostomus catostomus*), and white sucker (*Catostomus commersonii*). Following removal of the enclosure, movements through the fishway were documented for brown trout, longnose dace, longnose sucker, and white sucker.

Action #2:

- Level 1 Action Category: Technical Assistance
- Level 2 Action Strategy: Technical Assistance
- Level 3 Action Activities: With individuals and groups involved in resource management decision making

Implementing fish passage at diversion structures in Colorado is a challenging process, due to design, funding, permitting, and legal constraints (Richer et al. 2015). Given these challenges, feasibility studies have been identified by project stakeholders as a means to evaluate conceptual alternatives for fish passage while building support among stakeholders. We will provide technical assistance for the following feasibility studies: (1) the Whitney and BH Eaton Fish Passage Project on the Cache la Poudre River and (2) the Fish Passage and Ditch Diversion Resiliency Project on St. Vrain Creek. The objective of these projects is to provide fish passage for all species present in the project reaches, including rainbow trout (*Oncorhynchus mykiss*), brown trout (*Salmo trutta*), and various forage species.

Action #2 Accomplishments:

We provided technical assistance for both of the feasibility studies listed above. The Whitney and BH Eaton Fish Passage Feasibility Study was completed during the fall of 2016. Implementing fish passage at both diversion structures would reconnect 13.1 miles of fish habitat within the Cache la Poudre River. The feasibility study provided 30% design alternatives for implementing fish passage at both structures. CPW provided fish passage criteria, baseline fisheries survey data, and technical guidance for the feasibility study. Project implementation is on hold until both ditch companies agree to acceptable designs from the feasibility study and funding sources for implementation are identified.

The Fish Passage and Ditch Diversion Resiliency Project on St. Vrain Creek is focused on developing a 90% design for fish passage at the Niwot Ditch and conducting a conceptual alternatives analysis for fish passage at the South Flat Ditch. The US Fish and Wildlife Service (USFWS) provided funding for the feasibility study in partnership with Trout Unlimited (TU), Boulder County, CPW, private landowners, and ditch companies. CPW has provided technical assistance to support project coordination, design, and permitting. Implementing fish passage at both diversion structures will reconnect 2.6 miles of critical fish habitat in St. Vrain Creek. The

90% design for the Niwot Ditch is currently being finalized with the intention of starting construction during the fall of 2017. The conceptual alternatives analysis for the South Flat will be finalized after completion of the 90% design for the Niwot Ditch.

Expected Results and Benefits

Most rivers in the Colorado are fragmented by numerous diversion structures that prevent upstream migration of sportfish, adversely affect sediment transport, entrain downstream migrating fish in irrigation ditches, and sporadically dry up river segments during periods of drought or baseflow. The loss of rainbow trout (*Oncorhynchus mykiss*) and brown trout (*Salmo trutta*) from fragmentation and entrainment is economically costly and represents a loss of public recreation opportunity when fish are unavailable for capture and/or harvest. Fish passage research is focused on evaluating the effectiveness of fish passage structures and the impact of diversion structures on aquatic habitat, as well as the development of species-specific design criteria to improve connectivity in Colorado rivers and streams.

References

Krone, E., E.E. Richer, F.B. Wright, M.C. Kondratieff, and A.J. Treble. 2017. Crossing barriers: evaluation of a rock ramp fishway at a water diversion structure. 2017 Joint Meeting of Utah and Colorado/Wyoming Chapters of the American Fisheries Society. Grand Junction, Colorado. February 22, 2017.

Richer, E.E., M.C. Kondratieff, and B.D. Swigle. 2015. Post-flood recovery assessment and stream restoration guidelines for the Colorado Front Range. Colorado Parks and Wildlife, Fort Collins.

Richer, E.E., E. Krone, F.B. Wright, M.C. Kondratieff, and A.J. Treble. *In preparation*. Evaluation of a rock ramp fishway at the Fossil Creek Reservoir Inlet Diversion (FCRID) on the Cache la Poudre River. Colorado Parks and Wildlife, Fort Collins.

Job 3: Whitewater Park Studies

Need

With more whitewater parks than any other state, Colorado has become the epicenter for whitewater park design and construction. Whitewater parks contribute to local communities by providing revenue from tourism, promoting public interest in rivers, and creating additional recreational opportunities. However, whitewater parks can create hydraulic conditions that impair upstream migration of fish (Stephens et al. 2015; Fox et al. 2016) and create unfavorable fish habitat (Kolden et al., 2015). As a variety of whitewater park designs are being used throughout Colorado, CPW will build upon previous research by studying different types of structures and their effects on rainbow trout (*Oncorhynchus mykiss*) and brown trout (*Salmo trutta*) populations and habitat.

Objectives

1. Survey and quantify salmonid populations at two whitewater parks sites to evaluate impacts on fish passage and habitat by June 30, 2017.
2. Survey channel morphology and hydraulics at two whitewater parks sites to evaluate impacts on fish passage and habitat by June 30, 2017.
3. Results and analysis will be collated from multiple studies with the goal of producing management tools for development of fish-friendly whitewater parks (multi-year analysis).

Approach

Action #1:

- Level 1 Action Category: Data Collection and Analysis
- Level 2 Action Strategy: Research, survey or monitoring – fish and wildlife populations
- Level 3 Action Activities: Abundance determination; Age, size, and sex structure

Conduct Before-After studies on two new whitewater parks. Study sites are the Montrose Whitewater Park on the Uncompahgre River and the Gore Canyon Whitewater Park at Pumphouse on the Colorado River. Fish populations will be monitored with the assistance of biologists and researchers before and after construction of the whitewater parks to evaluate their impact on trout fisheries.

Action #1 Accomplishments:

The Montrose whitewater park was constructed during the winter of 2015-2016 and includes six channel-spanning structures. Each structure consists of a pre-cast concrete block placed in center of the channel with boulder wing walls extending laterally to each bank. Fishways were incorporated into one of the boulder wing walls at each structure. Fish sampling sites were established upstream, within, and downstream of the Montrose whitewater park. Upstream and downstream sites were not impacted during whitewater park construction and will serve as control sites for comparison to the whitewater park reach. One year of baseline monitoring data was collected at all three sites prior to construction. The second year of post-construction fish sampling was completed in November 2016. Monitoring data will be used to determine if the whitewater park structures alter fish populations, habitat, or passage. Post-construction monitoring will continue for a minimum of three years.

The Gore Canyon Whitewater Park at Pumphouse consists of a single channel-spanning structure that splits flows into two chutes. One chute was intended to accommodate fish and drift-boat passage. The other chute was designed to provide whitewater recreation for kayaks and stand-up paddleboards (SUP). Construction of the project was completed during the spring of 2015. Fish sampling was conducted within the project reach during the fall of 2014 to establish one year of baseline, pre-construction data. The second year of post-construction fish sampling was completed in September 2016. Fish sampling data will be used to determine if the whitewater park structure has altered fish populations upstream or downstream of the structure and provide

evidence if the structure has inhibited upstream fish passage. Post-construction monitoring will continue for a minimum of three years.

Action #2:

- Level 1 Action Category: Data Collection and Analysis
- Level 2 Action Strategy: Research, survey or monitoring – habitat
- Level 3 Action Activities: Baseline inventory; Monitoring

Impacts to habitat quality and fish passage will be assessed by surveying water depth and velocity with an ADCP before and after project construction. In addition, topographic surveys will be conducted before and after construction to evaluate changes in channel morphology. Survey data will also be used to configure 2D models for assessing changes in habitat suitability across a range of flows. Results for ADCP measurements and 2D modeling will be combined to elucidate if whitewater construction has affected fish passage or habitat quality at these study sites.

Action #2 Accomplishments:

Survey data from the Montrose whitewater park on the Uncompahgre River were used to configure and calibrate HEC-RAS models for both pre-project and post-project conditions. Results from HEC-RAS models will be used to evaluate changes in channel morphology and hydraulics, as well as inform boundary conditions for River2D habitat models. Configuration and calibration of 2D models is currently ongoing. Results from hydraulic modeling will be used to evaluate the impact of whitewater park implementation on habitat suitability and fish passage. Data analysis and synthesis for the Montrose Whitewater Park should be completed during the next reporting cycle.

Multiple surveys were conducted at the Gore Canyon Whitewater Park at Pumphouse on the Colorado River during previous reporting periods. Topographic and bathymetric surveys were conducted to document post-project channel morphology. An ADCP was used to measure water depths and velocities throughout the project reach to provide calibration and validation data for hydraulic and habitat models. Survey data were used to configure and calibrate HEC-RAS and River2D models for both pre-construction and post-construction conditions. The before-after comparison will evaluate the impact of whitewater park implementation on habitat suitability and fish passage.

Fish passage at the Pumphouse Whitewater Park was evaluated by comparing modeled depths and velocities to fish passage criteria for juvenile, average-adult, and large-adult brown trout, mottled sculpin (*Cottus bairdii*), rainbow trout, and white sucker (*Catostomus commersonii*). Velocities and depths were extracted from 2D modeling results along transects (i.e., cross-sections) through the area of highest velocity for a given flow. The area of highest velocity was targeted to evaluate if the whitewater park structure was creating a burst-velocity barrier. The same transect lines were used to compare pre-construction and post-construction conditions for each flow included in analysis. Data processing and analysis has been completed for the Pumphouse Whitewater Park and preliminary results were presented at the CO/WY/UT AFS meeting (Hillard et al. 2017).

Analysis of fish passage results for the Pumphouse whitewater park indicate that the amount of passable width along analysis transects declined by 82-99% for mottled sculpin, 89-100% for white sucker, and 21-94% for brown trout, depending on the life stage (juvenile, average adult, and large adult) and streamflow (300, 500, 850, 1,500, and 2,500 cfs). The amount of passable width increased by 126% for juvenile rainbow trout for one of the analyzed flows (i.e., 1,500 cfs), but declined by 22-100% for all other flows and life stages included in the analysis. The decline is passable width was statistically significant (p-value < 0.05) for all species and life stages, with the exception of juvenile white sucker. The decline in passable width was not significant for juvenile white sucker because a relatively small portion of the analysis transect was considered passable under pre-construction conditions. The 99-100% declines in passable width indicates that the Pumphouse whitewater park structure may be a complete migration barrier for some mottled sculpin, white sucker, and rainbow trout under certain flow conditions. Fish passage and habitat analyses from the Pumphouse and Montrose whitewater park studies will be synthesized into a single publication that will submitted for peer-review in 2017 or 2018.

Action #3:

- Level 1 Action Category: Technical Assistance
- Level 2 Action Strategy: Technical Assistance
- Level 3 Action Activities: With individuals and groups involved in resource management and decision making

As research scientists, our responsibilities include disseminating research results to promote science-based resource management decisions to whitewater park designers, water management agencies, and aquatic resource management agencies.

Action #3 Accomplishments:

Previous whitewater park research was conducted at the Lyons whitewater park on the North Fork of St. Vrain Creek. These research projects produced three peer-reviewed publications (Kolden et al. 2015, Stephens et al. 2015; Fox et al. 2016) and four theses (Fox 2013; Kolden 2013; Stephens 2014; Ryan 2015) to provide the foundation for scientifically defensible management tools and development of fish-friendly whitewater parks. These publications provide insight into potential impacts on fish passage, fish habitat, and methods for assessing fish passage using 2D and 3D hydraulic modeling methods. The Lyons whitewater park was destroyed during flooding in 2013 and was reconstructed during 2016. The reconstruction of the Lyons whitewater park provided an opportunity to compare fish passage analyses for the old and new whitewater parks using similar methodology. Analysis of the new whitewater park in Lyons in being conducted in cooperation with Colorado State University, similar to previous studies. Part of this analysis includes developing management tools for evaluating whitewater parks and informing fish-friendly whitewater park designs. Fish passage analysis for the new Lyons whitewater park and development of management tools is ongoing and should be completed in 2018.

Expected Results and Benefits

Information from this study is being used to determine the impact of whitewater park construction on rainbow trout (*Oncorhynchus mykiss*) and brown trout (*Salmo trutta*) populations, habitat, and movement. In addition, results will be used to develop design guidelines for whitewater parks that optimize both recreational and ecological benefits.

References

Fox, B. 2013. Eco-hydraulic evaluation of whitewater parks as fish passage barriers. M.S. Thesis, Department of Civil and Environmental Engineering, Colorado State University.

Fox, B.D., B.P. Bledsoe, E. Kolden, M.C. Kondratieff, and C.A. Myrick. 2016. Eco-hydraulic evaluation of whitewater parks as a fish passage barrier. Journal of the American Water Resources Association. DOI: 10.1111/1752-1688.12397.

Hillard, A.B., E.E. Richer, D.A. Kowalski, and M.C. Kondratieff. 2017. Surf's up fishes: evaluating fish passage at the Gore Canyon Whitewater Park at Pumphouse on the upper Colorado River. 2017 Joint Meeting of Utah and Colorado/Wyoming Chapters of the American Fisheries Society. Grand Junction, Colorado. February 22, 2017.

Kolden, E. 2013. Modeling in a three-dimensional world: Whitewater park hydraulics and their impact on aquatic habitat in Colorado. M.S. Thesis, Department of Civil and Environmental Engineering, Colorado State University.

Kolden, E., B.D. Fox, B.P., Bledsoe, and M.C. Kondratieff. 2015. Modelling whitewater park hydraulics and fish habitat in Colorado. River Research and Applications, DOI: 10.1002/rra.2931.

Ryan, E.R. 2015. Effects of hydraulic structures on fish passage: an evaluation of 2D vs 3D hydraulic analysis methods. M.S. Thesis, Department of Civil and Environmental Engineering, Colorado State University.

Stephens, T.A. 2014. Effects of whitewater parks on fish passage: a spatially explicit hydraulic analysis. M.S. Thesis, Department of Civil and Environmental Engineering, Colorado State University.

Stephens, T.A., B.P. Bledsoe, B.D. Fox, E. Kolden, and M.C. Kondratieff. 2015. Effects of whitewater parks on fish passage: a spatially explicit hydraulic analysis. Ecological Engineering 83:305-318.

Job 4: Development and Evaluation of a Radio Frequency Identification and GPS System

Need

RFID systems have been used in small, wadeable rivers to detect fish using both stationary and mobile designs. Mobile radio-frequency identification (RFID) systems that detect passive integrated transponder (PIT) tags can be used to analyze survival of aquatic species, fish movement patterns, and habitat utilization (Fetherman et al., 2014). Incorporating mobility and GPS technology into RFID systems can link the spatial distribution of fish to individual characteristics, such as species, length, and weight. Combining individual characteristics with spatial data has a vast range of research possibilities, including seasonal patterns in fish migration, the effects of instream barriers on fish migration, habitat utilization by species and age-class, mark-recapture population estimates, the response of aquatic organisms to climate change, as well as the impact of land use on aquatic species. Mobile RFID systems may also be used to evaluate PIT-tag retention and inform the design of future fish-movement studies.

Objectives

1. Conduct one study that utilizes the mobile RFID-GPS system to evaluate seasonal movement patterns for rainbow trout (*Oncorhynchus mykiss*) and brown trout (*Salmo trutta*) by June 30, 2017.

Approach

Action #1:

- Level 1 Action Category: Data Collection and Analysis
- Level 2 Action Strategy: Research, survey or monitoring – fish and wildlife populations
- Level 3 Action Activities: Movement

The RFID-GPS system will be deployed on the Middle Fork South Platte River near Hartsel, Colorado. The system will be deployed in study reaches at select times to evaluate seasonal movement patterns, reach-scale habitat utilization for trout, and issues with PIT-tag retention.

Action #1 Accomplishments:

The RFID-GPS system was deployed within project reaches during October 2016. Detection data from the RFID-GPS system will be combined with detection data from four fixed antenna sites to evaluate trout movement patterns. Data collection for this project was completed during the spring of 2017 when all fixed antenna sites were decommissioned. Preliminary results indicate that some brown trout (*Salmo trutta*) are migrating at least 25 river miles to access spawning habitat, whereas some rainbow trout (*Oncorhynchus mykiss*) are migrating at least 21 river miles to access spawning habitat. These finding are critically important for evaluating the importance of longitudinal connectivity in Colorado rivers and streams, where the prevalence of diversion structures and other barriers has severely fragmented aquatic habitat. The RFID-GPS system has also proven useful for evaluating issues with PIT-tag retention in salmonids. Methods development for the RFID-GPS system was submitted for peer-reviewed publication in the North American Journal of Fisheries Management during this reporting period (Richer et al. *In review*).

Future research will focus on comparing trout movement patterns to individual characteristics (species, length, spotting-pattern, age, sex, genetics, and diet) with the intention of producing additional peer-review publications by 2019.

Expected Results and Benefits

This study will help identify the strengths and limitations of the mobile RFID-GPS system for detecting PIT-tagged fish in natural river systems. In addition, detection data should elucidate seasonal migration patterns for rainbow trout (*Oncorhynchus mykiss*) and brown trout (*Salmo trutta*). Data will used to evaluate migration patterns, reach-scale habitat utilization by species and size class, and PIT-tag retention by species and size class.

References

Fetherman, E. R., B. W. Avila, and D. L. Winkelman. 2014. Raft and floating radio frequency identification (RFID) systems for detecting and estimating abundance of PIT-tagged fish in rivers. North American Journal of Fisheries Management 34(6): 1065-1077, DOI: 10.1080/02755947.2014.943859.

Richer, E.E., E.R. Fetherman, M.C. Kondratieff, and T.A. Barnes. *In review*. Incorporating GPS and mobile radio frequency identification to detect PIT-tagged fish and evaluate habitat utilization in streams. North American Journal of Fisheries Management.

Job 5: Technical Assistance

Need

CPW and other state and federal personnel are frequently in need of technical assistance related to stream habitat restoration, fish passage, whitewater park, and post-flood recovery projects. Technical assistance these projects will be provided, including project identification, selection, design, evaluation, and permitting. Technical assistance includes design review for CPW biologists and district wildlife managers (DWMs), site visits to proposed stream restoration locations, consultations with various agencies on stream restoration opportunities associated with highway and bridge improvement projects, project management, consultations and technical support related to stream mitigation work for 404 permits, technical assistance related to fish passage design and construction, and teaching at various technical training sessions for CPW and other state and federal personnel.

Objectives

1. Provide at least 10 technical assistance reviews to CPW personnel, NGOs, and Federal agency personnel as requested by June 30, 2017.

Approach

Action #1:

- Level 1 Action Category: Technical Assistance
- Level 2 Action Strategy: Environmental Review
- Level 3 Action Activities: Review of proposed projects

Review proposed stream habitat restoration and fish passage projects, including design, contractor selection, and permitting for CPW and other state and federal personnel as requested. Review proposed designs for post-flood road reconstruction and stream restoration for the Colorado Department of Transportation (CDOT) as requested. Provide training to CPW and other state and federal personnel on stream restoration techniques and fish passage design criteria, including guidance for permitting.

Action #1 Accomplishments:

We provided technical assistance for the following stream restoration, fish passage, and whitewater park projects:

1) South Boulder Creek Habitat Improvements Project
2) Ware and Hinds Fish Bypass, Elk Creek
3) Highlands Ditch Diversion Modification Project, White River
4) Gore Canyon Whitewater Feature at Pumphouse, Colorado River
5) Bohn Park Habitat Restoration Project, South Fork St. Vrain Creek
6) Fort Collins Whitewater Park, Cache la Poudre River
7) Native Fish Habitat Project, Dolores River
8) Arkansas River Diversion Rehabilitation Project
9) SB40 Certification, Highway 14 Bank Stabilization Project, Cache la Poudre River
10) Rio Grande River Headwaters Restoration Project
11) Conservation Barrier Project, Crooked Creek and Little Lime Creek
12) Basalt Whitewater Park, Roaring Fork River
13) Wines Ditch Barrier Project, Dolores River
14) Craig Whitewater Park, Yampa River
15) Steamboat Springs Whitewater Park, Yampa River
16) Eagle River Whitewater Park, Eagle River
17) Windy Gap Bypass Project, Colorado River
18) Colorado River Headwaters Project
19) Colorado Stream Quantification Tool
20) Stream Mitigation in the Colorado River Basin
21) Jackson Whitewater Park, Snake River, Wyoming
22) Salmon Whitewater Park, Salmon River, Idaho
23) Flushing Flows Assessment, Cache la Poudre River
24) Operation of Environmental Pool at Gross Reservoir, South Boulder Creek
25) Upper Colorado River Wild and Scenic Workgroup
26) Pine Valley Ranch Water Diversion Improvement, North Fork of the South Platte River
27) Timnath Reservoir Inlet Diversion Fish Passage Project, Cache la Poudre River

28) Watson Diversion Fish Passage Project, Cache la Poudre River
29) Lower Latham Ditch Project, South Platte River
30) Whitewater Park Creel Surveys, Roaring Fork River and Colorado River
31) Consolidated Dam Fish Passage Assessment, Rio Grande River
32) Applied Engineering Practices for Stream Restoration, Training Workshop, Rocky Mountain Stream Restoration Conference
33) Gunnison Tunnel Electric Fish Barrier Evaluation, Gunnison River

Expected Results and Benefits

As research scientists, part of our job is disseminating research results to promote science-based resource management decisions to resource users and other management agencies.

Personnel:

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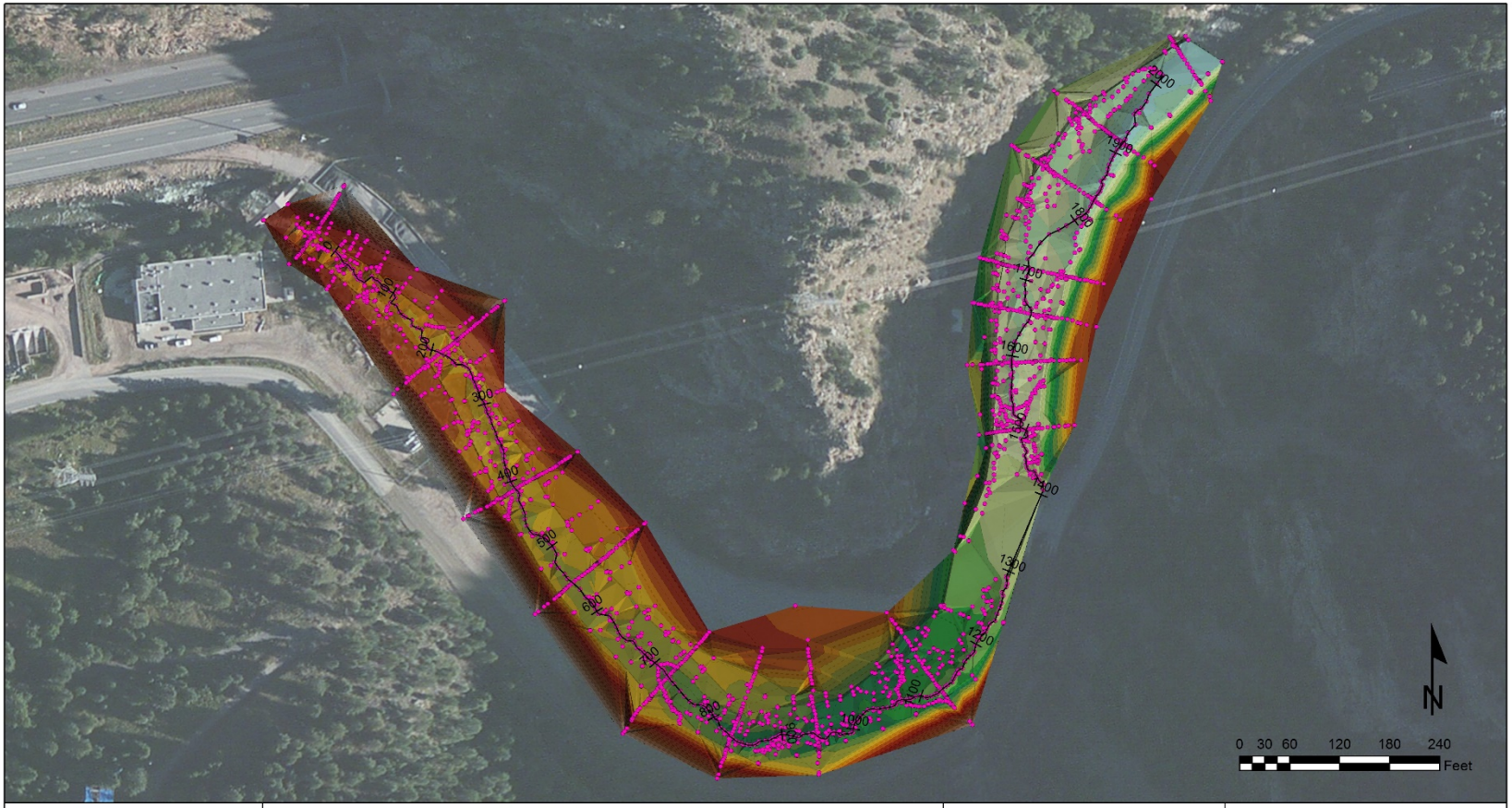
Eric E. Richer	CPW, Aquatic Research Scientist	970-472-4373
Technician	CPW, Technician	
James Guthrie	CPW, Financial Initiatives Program Manager	303-291-7563
George Schisler	CPW, Aquatic Research Leader	970-472-4361

Appendix A:

Topographic Surveys for Stream Restoration and Habitat Enhancement Projects



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7388 - 7390	7378 - 7380	7368 - 7370	7358 - 7360	7348 - 7350	Index Contour		
7386 - 7388	7376 - 7378	7366 - 7368	7356 - 7358	7346 - 7348	Survey Data		
7384 - 7386	7374 - 7376	7364 - 7366	7354 - 7356	7344 - 7346			
7382 - 7384	7372 - 7374	7362 - 7364	7352 - 7354	7342.43 - 7344			

AS-BUILT SURVEY 2016	
DRAWN: ERICHER	7/25/2017
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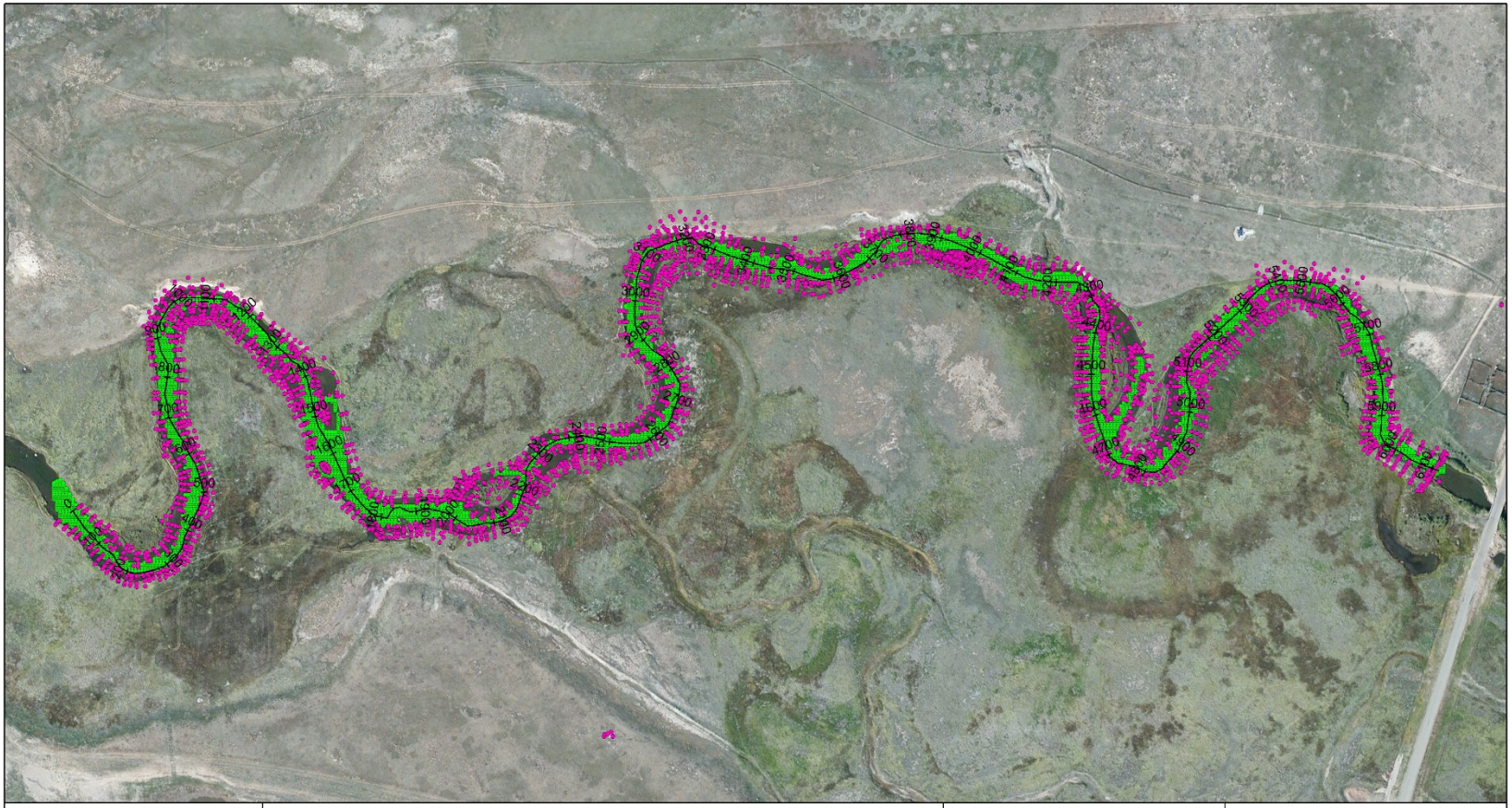
APPROVED:	
SHEET: 1 OF 1	

STATE OF COLORADO
DEPARTMENT OF NATURAL RESOURCES
COLORADO PARKS AND WILDLIFE
FORT COLLINS, COLORADO

TWIN TUNNELS HABITAT RESTORATION PROJECT
CLEAR CREEK



Legend

- Thalweg
- Survey Data
- ADCP Data

0 65 130 260 390 520 Feet

N

AS-BUILT SURVEY POINTS	
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STATE OF COLORADO
DEPARTMENT OF NATURAL RESOURCES
COLORADO PARKS AND WILDLIFE
FORT COLLINS, COLORADO

SOUTH PLATTE RIVER
DREAM STREAM
CHARLIE MEYER SWA