UPPER COLORADO RIVER ENDANGERED FISH RECOVERY PROGRAM

FY 2024-25 SCOPE OF WORK PROJECT: 177

Project Title
Green River physical habitat monitoring for experimental flows

Bureau of Reclamation Agreement Number:

R19PG00112 and R20PG00049

Reclamation Agreement Term
June 1, 2019 – September 30, 2023 (NPS) and October 1, 2019 – September 30, 2024 (USGS)

Lead Agency:
National Park Service, US Geological Survey

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Category:
_X_ Ongoing project
__ Ongoing-revised project
__ Requested new project
__ Unsolicited proposal

Expected Funding Source:
_X_ Annual funds
__ Capital funds
__ Other *[explain]*

Relationship to RIPRAP:

General
I.A.4.b.(1). Periodically monitor future channel narrowing and compare to historic rates using aerial or satellite imagery in the Green River (between Yampa and White rivers) [*and other rivers*]

Green River
I. Provide and Protect Instream Flows (Habitat Management)
I.D. Develop Study Plans to Evaluate Flow Recommendations
I.D.2.c. Develop Study Plan to evaluate revised base flows and flow spike.
I.D.2.f. Evaluate effect of base flow variability on backwater maintenance and quality.

Study Background/Rationale and Hypotheses:

The Upper Colorado River Endangered Fish Recovery Program is proposing new experimental flow releases from Flaming Gorge Dam for (1) revised summer base flows to promote survival and recruitment of age-0 endangered Colorado pikeminnow (Bestgen and Hill 2016a), and (2) early summer flow spikes to disadvantage spawning invasive smallmouth bass (Bestgen and Hill 2016b, Bestgen 2018). The proposed revised base flows are higher than previous base flows in dry years and restrict the range of preferred base flows both overall, and within all hydrologic categories compared to the Muth et al. (2000) base flow recommendations (Figure 1). These experiments will greatly reduce summer base flow variability. These experimental flows are in addition to the Larval Trigger Study Plan (LTSP), which recommends experimental flows to benefit razorback sucker larval survival by timing peak dam releases with the presence of larvae, which generally occurs later than the peak of the Yampa River. That ongoing study, which began in 2012, may result in reduced magnitude peak flows below the Yampa River, because dam releases are not timed to coincide with the peak of the Yampa River, although the duration of the peak releases may be extended. Reduced peak flows and flow stabilization have contributed to channel narrowing and simplification since Flaming Gorge Dam was constructed. The flow spike and base flow experiments coupled with possible associated reductions in magnitude or duration of peak flows could exacerbate the long-term trend of flow stabilization on the Green River. Flow stabilization has led to proliferation of vegetation including invasive tamarisk along the channel and associated sediment deposition, channel narrowing and channel simplification (Friedman 2018 and citations therein). Flow spikes could promote establishment of tamarisk due to its long seed production and germination window and disadvantage the recruitment of native cottonwoods that have a shorter seed production and germination period. Cottonwoods can outcompete tamarisk or at least hold their own when flows closely mimic a natural hydrograph. While both cottonwood and tamarisk seedlings would be scoured away in the zone below the peak of the spike, tamarisk may have greater opportunity to germinate new seedlings on the newly wetted surface due to their longer seed production period, which elevated base flows may allow to persist in dry years, if the seedlings don't dry out (Friedman, 2018). Also, any reduction in peak flow reduces the power of the river to scour sediment and vegetation and re-set the vegetation.

Channel narrowing and simplification threatens persistence and quality of backwater and side channel features needed by endangered fish. Use of high flows to remove unwanted vegetation is constrained by current operational guidance for Flaming Gorge Dam, which attempts to limit spills (i.e., releases greater than 8600 ft3/s). Therefore, reversing vegetation encroachment with current peak flow maxima is more likely to succeed if implemented while plants are still small, and vegetation is sparse. Peak flows in the range described in the 2006 ROD may be sufficient to remove new vegetation if they occur frequently enough, but a series of dry years such as experienced between 2000 and 2004 could allow vegetation to grow large enough to resist scouring. Low base flows in some low water years helps to prevent vegetation establishment by desiccating young plants that can't reach the water table. Elevated base flows in all low water years may not allow this desiccation to take place. However, permanently wetted areas below the elevated base flows will not allow vegetation establishment in that zone, so the zone of potential vegetation establishment is fairly narrow, above the elevated base flows. The proposed annual monitoring of near-channel vegetation and topography will focus on this sensitive zone at selected sites and attempt to describe changes in vegetation as they occur on an annual basis so that changes observed can be attributed to that year's flow. This would enable managers to prescribe a timely response in case the proposed flow experiments lead to vegetation encroachment and habitat degradation (Friedman

2018), or to determine if the proposed experiments have neutral or positive effects on habitat and channel morphology. For example, if results indicated that vegetation was encroaching, in subsequent years it might be more important to make sure the two rivers combined resulted in a high peak flow than to peak the Green river based on the presence of larval fish. If there are multiple consecutive years where the elevated base flows are predicted to be similar in the upcoming year, it might be worth skipping a year of the elevated base flows for fish to ensure a different base flow that would make vegetation more likely to be scoured, drowned, or desiccated. Alternatively, if several consecutive years of stable elevated base flows are not resulting in vegetation encroachment or loss of backwater habitat, there would be no reason for the experiment not to proceed despite it being predicted to be a similar base flow as previous years.

The Recovery Program Biology Committee approved a flow spike study plan including the timing, magnitude and frequency of ‘flow spikes’ and the response of the fish community, primarily the targeted smallmouth bass (Bestgen 2018). A base flow study plan including timing, magnitude and frequency of flows and the response of the fish community, primarily Colorado pikeminnow larvae and juveniles, has been finalized. A channel and vegetation monitoring study plan that can evaluate the physical effects of both flow spikes and revised summer base flows in the context of the present peak flow regime was finalized in 2020. This SOW addresses the needed channel and vegetation monitoring.

Friedman (2018) reviewed and summarized the underlying theories and mechanisms leading to the potential for the experimental flows to lead to continued vegetation encroachment and channel simplification. He also recommended components of a monitoring plan that would track changes through time, potentially allowing for experimental flows to be revised, suspended, or halted if unacceptable impacts are observed. A workshop organized by NPS in April 2019 gleaned additional input on recommended monitoring strategies from various subject matter experts, including technical experts in channel morphology, sediment transport, and riparian vegetation.

We recognize that it may be difficult to separate the effects of the flow experiments from ongoing channel simplification, however published research in the Colorado River basin shows that stabilization of flows results in vegetation encroachment. Initial unpublished results from two years of flow spikes and the annual hydrology have not resulted in woody recruitment at Island Park, however we think that when conditions are right, woody encroachment could still occur from flow spikes. Three years of modified base flows with low variability occurring in years with small annual peak flows may be contributing to an increase in vegetation cover at the six sites in the Jensen to Ouray Reach. Therefore, we think it is warranted to continue monitoring that is intended to identify if flow related mechanisms lead to vegetation establishment which in turn leads to channel simplification.

The NPS Northern Colorado Plateau Network (NCPN) implemented a monitoring program to track channel and vegetation changes in Dinosaur National Monument (NM) in 2010 and in Canyonlands National Park in 2014 (Perkins et al. 2018). We propose continuing the monitoring supported in this SOW to supplement data collection at those existing monitoring sites and using similar methods outside NPS lands in areas where critical nursery habitat for Colorado pikeminnow occurs. NPS conducted a reconnaissance visit in 2019 to select sites and then USGS and NPS have done three years of work in 2020, 2021, and 2022. Funding is in place for field work in 2023.

Study Goals and Objectives:

Goals

1. Establish channel vegetation and channel condition monitoring sites at selected locations
2. Detect changes in channel vegetation and channel form that may lead to simplified channel morphology and degrade backwater habitat from baseflow experiments and any potential reduction in peak flows in Dinosaur NM, and in known areas of Colorado pikeminnow nursery habitat below the Yampa River confluence
3. Determine if flow spike experimental flows are altering the recruitment rates of woody vegetation (cottonwood and tamarisk) in Dinosaur NM.

Objectives

1. Continue annual monitoring to evaluate changes to vegetation and channel characteristics
2. Evaluate monitoring data annually and meet with decision-makers to develop recommendations for the prescribed flows, adjustments in experimental flow management, or other measures, which may address concerns about vegetative encroachment, channel simplification, or habitat loss.

End Products

1. Database of measurements
2. Annual reports by due date set by the Recovery Program (mid-November) summarizing results and recommending potential adjustments in experimental flows if needed
3. Periodic summary reports as needed (e.g. after 3 or more consecutive years of similar hydrology and base flows) describing changes in vegetation and channel form at the monitoring sites, evaluating the likely causes, and identifying potential mitigation strategies, offsetting measures, and experiment cessation points if thresholds are met and a positive fish response is not observed. A report summarizing four years of work is due in December 2023 under existing agreement.

Study Area:

Three reaches of the Green River from upstream boundary of Dinosaur NM, downstream to confluence with Colorado River in Canyonlands NP. NPS will continue funding for existing monitoring in Dinosaur NM and Canyonlands NP. This SOW addresses additional monitoring to be added in the Dinosaur NM, and the Jensen to Ouray Reach.

1. Dinosaur NM is monitored by NPS (NCPN) as part of on-going “Big-River Program.” Dinosaur NM will be the sole focus of measuring the effects of the flow spikes on cottonwood and tamarisk generation and will be monitored as well for changes resulting from the experimental summer baseflows.

2. Jensen to Ouray – Six sites were established in this Colorado pikeminnow nursery habitat area. These sites will be used to evaluate the experimental summer base flows and any potential changes in peak flows.
3. Canyonlands NP is monitored by NPS/NCPN as part of on-going Big-River Program. These existing sites will be used to evaluate responses to the experimental flow management and any potential changes in peak flows.

Study Methods/Approach

A number of direct and indirect metrics may be used to assess changes in channel width and form and the processes that affect these features. Over time, channel width and form are a function of streamflow, sediment supply and transport, and riparian vegetation, and these factors should be measured and monitored to evaluate the processes that may result in changes. The conversion of active-channel surfaces to less active, more stable surfaces is a hallmark of channel narrowing (Graf 2006), often intimately related to the establishment of riparian vegetation. Direct measures of channel narrowing often involve repeated topographic surveys at permanently located channel and floodplain cross-sections over time. Such direct measures can provide detailed and temporally rich information on localized channel change, but often are spatially limited, making it difficult to infer change at larger spatial scales (Moody et al. 1999, Allred and Schmidt 1999). Annual aerial photographs can provide an indirect but spatially integrated quantification of channel change over larger areas as it relates to annual flows, but aerial photography is generally collected with low temporal resolution to provide a more detailed interpretation of floodplain formation and related channel narrowing (Graf 1978, Merritt 1997, Grippo 2017) and can be cost-prohibitive. Some combination of fine- and coarse-scale analyses of channel narrowing can provide a more robust interpretation (Manners et al. 2011, Dean and Schmidt 2011). The NPS Northern Colorado Plateau Network (NCPN) focused its 'Big River' monitoring efforts on hydrologic, geomorphic, and vegetation changes because these provide strong, robust, measurable indications of the channel-narrowing process, and combined both fine and coarse-scaled analyses. Other aridland riparian methods were reviewed, evaluated, and determined to not be of sufficient rigor or repeatable by NCPN. Due to the extensive lengths of rivers in remote settings within NCPN parks and the limited resources available for monitoring, we sought to focus most of our effort on detailed annual monitoring at a select number of sites (sentinel sites) that we hypothesize are sensitive to potential changes in streamflow.

<u>Revised Base Flow Monitoring</u>

The NCPN sampling protocol outlines a process for establishing long-term sample sites called sentinel sites. Each sentinel site consists of a significant habitat feature such as a side channel or backwater, and surrounding topography and vegetation. Measurements of vegetation, hydrologic, and physical drivers are co-located at each sentinel site and monitored concurrently. The size of a sentinel site is dependent on geomorphic features affected by the river's peak and annual flow, and the constraints (canyons) that allow or restrict the river channel's movement. Currently NCPN has 9 sentinel sites in Dinosaur National Monument (6 on the Green River and 3 on the Yampa) 9 sites at Canyonlands National Park (6 on the Green and three on the Colorado), and six sites between Jensen and Ouray, UT. Sites were chosen based on logistics, safety, presence of legacy data, significant sources, and sensitivity to fluvial geomorphic change and subsequent channel narrowing. Sample sites outside of park lands in riverine nursery habitat areas will be chosen with similar criteria, including persistent presence of Colorado pikeminnow nursery habitat backwaters and side channels. Annual sampling allows us to detect the effects of annual flows, sediment supply, and other factors within one year after they occur. Sampling of vegetation and geomorphology occurs during summer baseflow, after vegetation has reached peak growth (July– September). Surface water depths will be continuously monitored with transducers at all sites. Information from the transducers will be collected once each year during the physical monitoring trips.

We implemented 6 sites in the Jensen to Ouray reach in 2020 to establish baseline and ongoing monitoring of channel features and vegetation including backwater nursery habitat at those sites. At each site, several transects were established and repeat surveys have taken place from 2020 to 2022 with plans in place for 2023. Survey plots ($1m^2$) were established along the transects similarly to how sites were established in Canyonlands NP (Perkins et al. 2018), with a focus on establishing the plots at elevations most likely to be affected by the experimental flows. At each plot, total and individual species percent cover area will be determined, as well as sediment grain size. Each plot will also be surveyed with RTK to determine elevation. Air and water transducers will be permanently located to aid in determining the number of days per year of inundation on each plot. A thorough description of methods to establish the transects and survey plots, data collection and storage, and analysis is given in Perkins et al. (2018).

Repeated digital analysis of historic and more recent aerial photography has revealed channel narrowing and simplification occurring in the Green River over several decades (Grippo 2017, Manners et al. 2011). Comparison with future aerial imagery will allow us to track changes in the future as well, at fairly fine resolution, and perhaps determine if channel simplification continues, ceases, or reverses. A NASA/NPS partnership has developed codes for using remote satellite imagery to track these changes as well. Currently the finest resolution for this method is $100m^2$, which is a coarser-scale analysis than will allow for early detection of vegetation establishment on recently deposited sand surfaces. However, it can show river-wide changes. Worldview satellite may be added in the future, improving resolution to 33 cm making this application useful on a shorter time scale.

For this SOW we propose to partner with the USGS in the use drone technology to capture fine scale imagery of areas including and adjacent to the sentinel sites to capture changes at a larger scale than the transect sites. Chris Holmquist-Johnson of USGS, Fort Collins has the necessary expertise to capture and analyze the imagery to distinguish between bare sand, water, and vegetation, and evaluate changes in sizes, area, and distribution of age 0 CPM habitat. This effort has been conducted annually in conjunction with the physical monitoring trips.

We will also continue obtaining WorldView Satellite Imagery. The USGS can request to task these satellites every year within a specified time window of one month free of charge to cover the necessary area. The WorldView product includes panchromatic imagery at a resolution of 33 cm, which is superior to the 1-m resolution of NAIP that had been used in the past by Grippo (2017) for monitoring backwaters. The WorldView product also includes 8-band multispectral imagery at 1 m resolution that could be used to calculate NDVI (Normalized Difference Vegetation Index). This would provide a straightforward annual measurement of vegetation encroachment at the scale of a long reach. Furthermore, for most years NAIP imagery collected during the base-flow period is not available, while the WorldView can be tasked during base flows, which is essential for matching field data to remote sensing data at similar flows.

Flow Spike Monitoring

The primary concern of the flow spike is that it could promote the germination and establishment of non-native tamarisk on bare sand areas at the expense of cottonwoods that have a shorter germination period. The flow spike, which would likely be implemented between late June and the end of July in years where conditions are favorable, is outside of the window for cottonwood germination so it could potentially remove new cottonwood seedlings and allow for new germination sites for tamarisk. In low flow years, this is likely less of an issue as next year's peak flow will likely scour any new seedlings of cottonwood or tamarisk. However, if there are multiple low peak flow years and a stabilization of base flows over a number of years, there is the potential for tamarisk to establish and grow larger and then be able to resist scour from higher peak flows. Conversely, the relatively rapid fall in stage associated with the proposed flow spikes may inhibit the establishment of new vegetation at the affected bank elevations. The primary area of concern for the flow spike is Dinosaur National Monument as we think the effects of the spike flow will attenuate and be minimized farther downstream.

We propose an additional monitoring trip occur after the spring peak but before the spike flow. This pre-spike trip should occur as close to the flow spike as logistics allow. This trip will focus on existing sites at Brown's Park, Echo Park, and Island Park. Additional sites may be needed. At existing sites we will focus on the 1m^2 plots established at the targeted elevations inundated by discharges between the base flow and approximately 5600 cfs (slightly above the flow spike peak). Crews will only be seeking to collect census data on woody tree species tamarisk and cottonwood. The post-spike flow trip will occur at the same time as the existing base flow monitoring occurs (at the expense of NPS) to evaluate survival and mortality of woody species after the flow spike.

Summary of monitoring methods and schedule

Flow spike monitoring

a) Pre-spike survey of cottonwood and tamarisk germination sites: June (dependent on hydrology, post-peak, pre-spike, should be as close to spike as logistics allow). Locations are Brown's Park, Deerlodge, and Island/Rainbow Park.

b) Post-spike survey of cottonwood survival – in conjunction with annual NCPN trips (funded by NPS) that will also monitor base flow sampling trips in July/August

Revised base flow monitoring

a) Established NPS monitoring sites will be sampled on current schedule in July/August/September. Six sites are located in the Jensen to Ouray reach as recommended due to it being important nursery habitat for Colorado pikeminnow (Bestgen 2016a,b).

b) High-resolution remote sensing data (natural color and possibly multispectral) will be acquired annually during base flow conditions using drones at each of the sentinel sites, and 'worldview' satellite imagery will be requested at the reach scale level. The high-resolution imagery (sub meter) will be used to assess both local and reach scale channel/habitat change over time.

Task Description, Deliverables and Schedule:

Task 1. Pre-flow spike treatment monitoring trip
Task 2. Post flow spike and baseline base flows monitoring trip.
Task 3. Annual report and assessment of impacts.
Task 4. Three-year summary report
Task 5. Collect and analyze drone imagery.

FY24 Annual Report due Nov 30, 2024
FY25 Annual Report due Nov 30, 2025
FY26 Annual Report due Nov 30, 2026
FY26 Six Year summary report due Dec, 2026
FY27 Annual Report due Nov 30, 2027
FY28 Annual Report due Nov 30, 2028

Budget Summary:

FY24-25	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Task 1						X						
Task 2								X	X			
Task 3											X	
Task 4												
Task 5								X	X			

FY25-26	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Task 1						X						
Task 2								X	X			
Task 3												
Task 4												X
Task 5								X	X			

[Note: PI's are REQUIRED to prepare their budget in the Cost Estimating Tool (to facilitate funding of projects from Bureau of Reclamation). Here, provide total AND subtotals by funding target (e.g., office/station) from those tables.]

FY Year	*NPS*	*USGS*
2024	$51,530.79	$71,133.60
2025	$83,611.45	$71,859.86
2026	$70,127.83	$79,174.06
2027	$55,029.20	$76,739.03
2028	$73,279.17	$78,408.43
Total	$333,578.44	$377,314.97

Reviewers:

This project is ongoing, not revised.

References:

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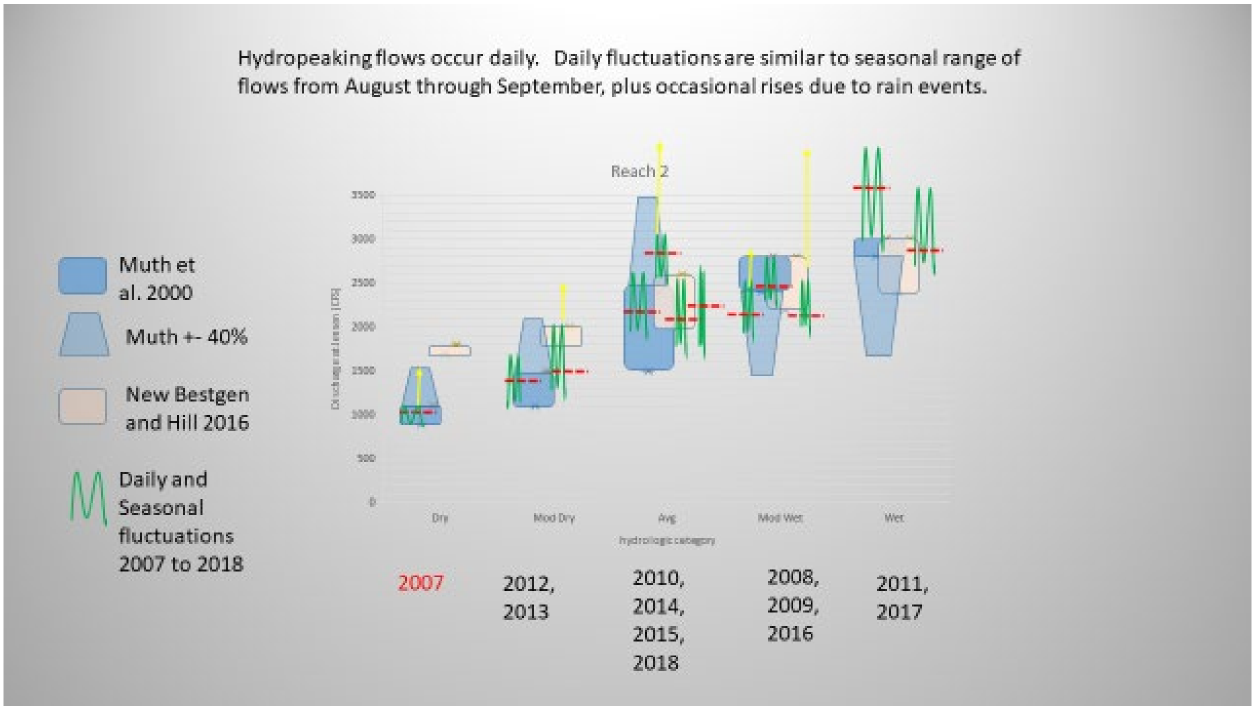

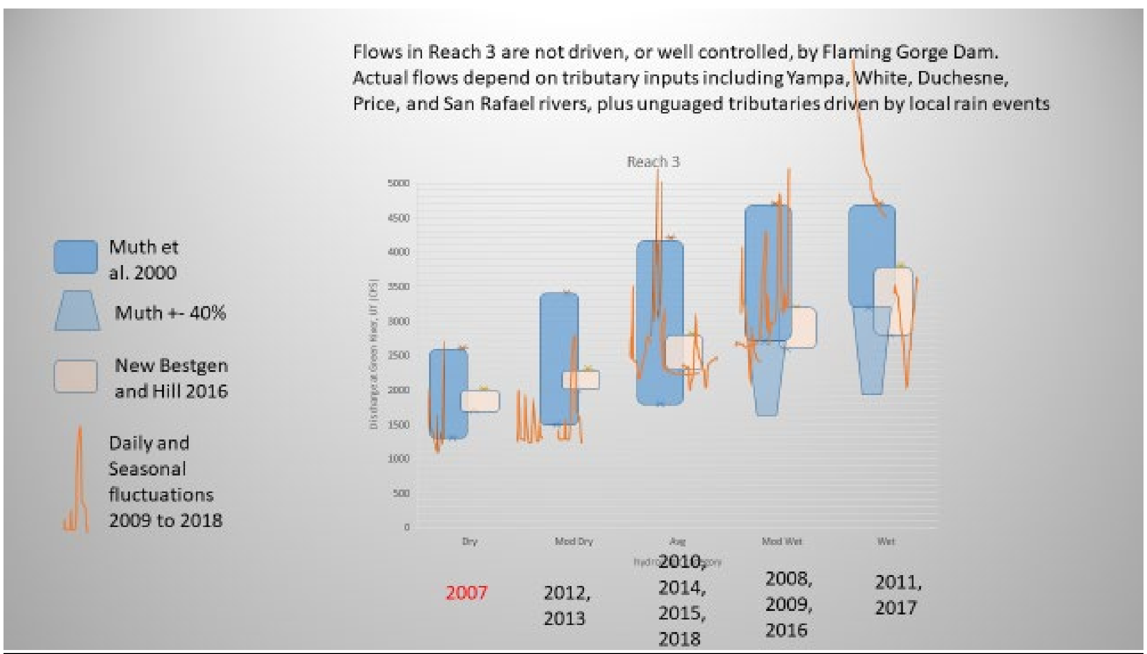

Figure 1. Old (Muth et al. 2000) and new proposed (Bestgen and Hill 2016) base flow recommendations for Reaches 2 and 3, in the Green River, UT. Also shown are the range of the +-40% of flows based on Muth et al. 2000 and ROD in the categories when that additional range of flows may be used to meet the revised recommendations, and the ranges of daily and seasonal fluctuations that have occurred during August and September for the most recent 10 years by hydrologic category. Red dashed lines in Reach 2 indicate mean August to September flows for each year from 2007 to 2018. Reach 2 fluctuations are primarily driven by load-following hydropeaking, and Reach 3 fluctuations are representations of the actual hydrographs from August through September in each year.

SUMMARY OF PROPOSED COSTS

Name of Servicing Agency: USGS Fort Collins Science Center

Project Name: 177 - Green River physical habitat monitoring for experimental flows

		FY24		FY25		FY26		FY27		FY28	
		YEAR 1		**YEAR 2**		**YEAR 3**		**YEAR 4**		**YEAR 5**	**TOTAL**
Enter the BEGINNING dates for each year ------>		**10/1/2023**		**9/30/2024**		**10/1/2025**		**10/1/2026**		**10/1/2027**	
		Through		Through		Through		Through		Through	
Enter the ENDING dates for each year ------->		**9/29/2024**		**9/30/2025**		**9/30/2026**		**9/30/2027**		**9/29/2028**	
DIRECT LABOR AND FRINGE BENEFIT COSTS:		**YEAR 1**		**YEAR 2**		**YEAR 3**		**YEAR 4**		**YEAR 5**	**TOTAL**
Direct Labor - Hourly		$ 46,316.80		$ 47,243.14		$ 55,909.85		$ 49,151.76		$ 53,414.13	$ 252,035.67
Fringe Benefits - Hourly		$ -		$ -		$ -		$ -		$ -	$ -
Subtotal of Direct Labor & Fringe Benefits:		**$ 46,316.80**		**$ 47,243.14**		**$ 55,909.85**		**$ 49,151.76**		**$ 53,414.13**	**$ 252,035.67**
OTHER DIRECT COSTS:		**YEAR 1**		**YEAR 2**		**YEAR 3**		**YEAR 4**		**YEAR 5**	**TOTAL**
Materials and Supplies		$ 500.00		$ 1,530.00		$ 520.20		$ 1,591.81		$ 2,164.86	$ 6,306.87
Travel Costs		$ 5,862.00		$ 5,979.24		$ 6,098.82		$ 6,220.80		$ 6,345.22	$ 30,506.08
Equipment		$ 3,500.00		$ 2,000.00		$ -		$ 3,641.40		$ -	$ 9,141.40
Contractors		$ -		$ -		$ -		$ -		$ -	$ -
Subtotal of Other Direct Costs:		**$ 9,862.00**		**$ 9,509.24**		**$ 6,619.02**		**$ 11,454.01**		**$ 8,510.08**	**$ 45,954.35**
INDIRECT/OVERHEAD COSTS:		**YEAR 1**		**YEAR 2**		**YEAR 3**		**YEAR 4**		**YEAR 5**	**TOTAL**
Subtotal of Labor and Other Direct Costs:		**$ 56,178.80**		**$ 56,752.38**		**$ 62,528.87**		**$ 60,605.77**		**$ 61,924.21**	$ 297,990.03
Total dollars exempt from indirect/overhead base:		$ -		$ -		$ -		$ -		$ -	
<Enter Description of Indirect/OH Cost #1>	**26.62%**	$ 14,954.80	**26.62%**	$ 15,107.48	**26.62%**	$ 16,645.19	**26.62%**	$ 16,133.26	**26.62%**	$ 16,484.22	$ 79,324.94
Total dollars exempt from indirect/overhead base:		$ -		$ -		$ -		$ -		$ -	
<Enter Description of Indirect/OH Cost #2>	**0.00%**	$ -	**0.00%**	$ -	**0.00%**	$ -	**0.00%**	$ -	**0.00%**	$ -	$ -
Subtotal of Indirect/Overhead Costs:		**$ 14,954.80**		**$ 15,107.48**		**$ 16,645.19**		**$ 16,133.26**		**$ 16,484.22**	**$ 79,324.94**
		YEAR 1		**YEAR 2**		**YEAR 3**		**YEAR 4**		**YEAR 5**	**TOTAL**
GRAND TOTAL:		**$ 71,133.60**		**$ 71,859.86**		**$ 79,174.06**		**$ 76,739.03**		**$ 78,408.43**	**$ 377,314.97**