Final Report for the Intermountain Center for River Rehabilitation and Restoration (ICRRR)

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The Intermountain Center for River Rehabilitation and Restoration (ICRRR) was created in 2006 by the Department of Watershed Sciences to help meet the challenge of reversing national trends in freshwater ecosystem degradation. The ICRRR was disbanded in 2015, and its activities were transferred to other research centers within the Department of Watershed Sciences. The mission of the ICRRR was to advance the science and practice of river restoration and environmental management and to transfer that knowledge to the public and private sectors by undertaking targeted research, teaching, and extension/outreach activities. The ICRRR had two foci: restoration practices of small streams and rehabilitation of intermediate and large rivers. The ICRRR focused its work in the western United States.

Earmark grants from the Department of Energy's Bureau of Energy Programs were essential in the success of the ICRRR in conducting its work and in accomplishing its mission of transforming the practice of small stream restoration and improving the work of adaptive management programs focused on large and intermediate rivers. The DoE earmark funding was essential in allowing the university to develop a strong focus in river restoration and to acquire essential infrastructure that allowed the ICRRR to conduct its work. Today, the legacy of the ICRRR is the existence of several new research groups in the Watershed Sciences Department whose missions are consistent with the original mission of the ICRRR.

A. Summary of Earmark Funding:

(1) FY 2007: *Establishment of the Intermountain Center for River Rehabilitation and Restoration at Utah State University.* $385,000. Initial Center funding was used to (1) hire a post-doctoral research associate who initiated studies in aquatic ecology related to stream restoration, and (2) support staff salaries, graduate student stipends, and research expenses focused on stream restoration and river rehabilitation. The Center integrated its work with scientists at Johns Hopkins University, University of California-Berkeley, University of Maryland, and University of Montana, and the Center developed and conducted a stream restoration short course in collaboration with instructors at those institutions.

(2) FY 2009: *Enhancement for the Intermountain Center for River Restoration and Rehabilitation*. $555,000. Partial salary was provided for the Director, a programmer, lab manager, staff assistant, and an NCED post-doctoral research scholar. Full stipends were provided for select graduate students. Critical research equipment was acquired. Travel expenses were incurred.

(3) FY 2010: *Enhancement for the Intermountain Center for River Restoration and Rehabilitation.* $583,000. Partial salary was provided for the Director, lab manager, staff assistant, and NCED post-doctoral research scholar. Stipends were provided to select graduate students. Additional lab equipment was acquired to facilitate river restoration research. Travel expenses were incurred.

B. Major ICRRR Activities:

(1) *Public outreach and short-course education programs.* The ICRRR solidified a program of short-course education that had begun in the Watershed Sciences Department in 2004. The ICRRR successfully conducted summer courses in every year that the Center existed, including in every year that earmark funding was received. These courses were coordinated with similar courses conducted by faculty at the University of California at Berkeley and at the University of

Maryland and Johns Hopkins University. These courses introduced students to general concepts of river restoration and the application of geomorphology, aquatic ecology, and riparian ecology to river restoration. Utah State University scientists from three different colleges were instructors in these courses.

Earmark funding allowed the ICRRR to fund a staff person to organize the logistics of course registration and administration. Funding also allowed the ICRRR to conduct preliminary field work and basic information that greatly improved the pedagogy of the short courses. Many of the field activities developed with the support of the earmark grants are used in short courses for outside professionals and courses taught at Utah State University. These field activities contributed to the development of methods that are used to better integrate restoration objectives and restoration actions. Approximately 10-30 students took the class each year, and there are similar enrollments in the courses being conducted today. Students who take these classes are employed by universities, consulting firms, NGOs, and government agencies. Students come from throughout the U. S. and from overseas.

Additionally, Dr. Joe Wheaton, associate professor, developed mini-short courses concerning geomorphic change detection and concerning the role of introduced beaver in river restoration. These courses were originally organized with support from the ICRRR, and these courses are still taught annually.

Once the ICRRR was disbanded, the short course program was incorporated into the activities of the Watershed Science Department and its component labs. The introductory restoration course is no longer taught at Utah State, but similar content is provided by the course taught by UC-Berkeley. Dr. Peter Wilcock, department head, and Dr. Patrick Belmont, associate professor, now teach a Utah State short course focused on addressing stream restoration in the context of a river’s sediment supply and sediment transport. This course’s content

is largely based on ICRRR-supported field work and subsequent short course series. Dr. Wheaton continues to teach the courses that he developed.

(2) *Creation of a post-project monitoring program and support for applied research for small stream restoration.* The ICRRR program in post-project monitoring and assessment developed methods for evaluation of the performance and success of rehabilitation and restoration projects. These methods were developed by ICRRR post-doctoral research associates and graduate students and are reported in peer reviewed publications. The goal of this work was to develop robust and efficient methods of evaluating whether projects meet their stated goals and objectives in the short and long term, as well as to determine the most efficient methods of achieving those goals.

The ICRRR supported research targeted on the problems and concerns of river managers and restoration design practitioners in the Intermountain West. These issues included ecological response to rehabilitation and restoration, the effects of gravel augmentation on channel habitat, delineation of areas where sediment supply may be a significant problem in channel design, and techniques to deal with water quality and geochemical problems in restoration.

Scott Miller, the first ICRRR post-doctoral researcher, invested a substantial amount of time working with the Utah Division of Wildlife Resources, in developing a an initial data base of stream restoration projects in Utah.

a. Key Publications:

i. Baillie, M. B., Salant, N. L., and Schmidt, J. C. 2011. Using a historical aerial photograph analysis to inform trout habitat restoration efforts. *Earth Surface Processes and Landforms* 36: 1693-1702.

ii. Erwin, S. O., Schmidt, J. C., and Allred, T. M. 2016. Post-project geomorphic assessment of a large process-based river restoration project. *Geomorphology* 270: 145-158. http://dx.doi.org/10.1016/j.geomorph.2016.07.018

iii. Erwin, S. O., Schmidt, J. C., Wheaton, J. M., and Wilcock, P. R., 2012. Closing a sediment budget for a reconfigured reach of the Provo River, Utah, USA. *Water Resources Research* 48, W10512. doi:10.1029/2011WR011035.

iv. Miller, S. W., Budy, P., and Schmidt, J. C. 2010. Quantifying macroinvertebrate responses to in-stream habitat restoration: applications of meta-analysis to river restoration. *Restoration Ecology* 18(1):8-19. doi:10.1111/j.1526-100X.2009.00605.x

v. Salant, N. L., Schmidt, J. C., Budy, P. E., and Wilcock, P. R. 2012. Unintended consequences of restoration: loss of riffles and gravel substrates following weir installation. *Journal of Environmental Management* 109:154-163. doi.org/10.1016/j.jenvman.2012.05.013.

(3) *Contributions to the rehabilitation of intermediate and large river rehabilitation.* ICRRR played significant roles in the (a) development of a bi-national program to rehabilitate the Rio Grande in the Big Bend region of Texas and Mexico; (b) management and rehabilitation of riverine resources of the Colorado River system, including in Grand Canyon National Park and Dinosaur National Monument; and, (c) management of the Snake River in Grand Teton National Park and Hells Canyon National Recreation Area. Many of these projects were initiated with earmark funding and continued with funding from the Bureau of Reclamation, National Park Service, Natural Resource Conservation Service, and U. S. Geological Survey. The ICRRR also focused a large body of research on understanding the dynamics and controls of valued fisheries of the Intermountain West and on the aquatic ecosystems that are their foundation. ICRRR worked in Arizona, California, Colorado, Idaho, Nevada, Oregon, Texas, Utah, Washington, and Wyoming under the leadership of Dr. Phaedra Budy. Dr. Budy and Dr. Schmidt collaborated with Spanish scientists on issues of fisheries and dam management, and Schmidt participated in a national assessment of the effects of controlled dam releases on downstream ecosystems (supported by the National Center for Ecological Analysis and Synthesis).

a. Key Publications:

i. Dean, D. J. and Schmidt, J. C. 2011. The role of feedback mechanisms in historic channel changes of the lower Rio Grande in the Big Bend region. *Geomorphology* 126 (3-4):333-349. doi:10.1016/j.geomorph.2010.03.009.

ii. Dean, D. J., Scott, M. E., Shafroth, P., and Schmidt, J. C. 2011. Stratigraphic, sedimentologic, and dendrogeomorphic analyses of rapid floodplain formation along the Rio Grande in Big Bend National Park, TX. *Geological Society of America Bulletin* 123(9/10):1908-1925. doi:10.1130/B30379.1.

iii. Erwin, S. O., Schmidt, J. C., and Nelson, N. C. 2011. Downstream effects of impounding a natural lake: the Snake River downstream from Jackson Lake Dam, Wyoming. *Earth Surface Processes and Landforms* 36(11):1421-1434. doi:10.1002/esp.2159.

iv. Gonzalez del Tanago, M., Bejarano, M. D., Garcia de Jalon, D., and Schmidt, J. C. 2015. Biogeomorphic responses to flow regulation and fine sediment supply in Mediterranean streams (the Guadalete River, southern Spain). *Journal of Hydrology* 528:751-762. http://dx.doi.org/10.1016/j.jhydrol.2015.06.065

v. Grams, P. E., Schmidt, J. C., Wright, S. A., Topping, D. J., Melis, T. S., and Rubin, D. M. 2015. Building sandbars in the Grand Canyon. *Eos* 96, doi:10.1029/2015EO030349.

vi. Konrad, C. P., Olden, J. D., Lytle, D. A., Melis, T. S., Schmidt, J. C., Bray, E. N., Freeman, M. C., Gido, K. B., Hemphill, N. P., Kennard, M. J., McMullen, L. E., Mims, M. C., Pyron, M., Robinson, C. T., and Williams, J. G. 2011. Large-scale flow experiments for managing river systems. Bioscience 61(12):948-959. doi:10.1525/bio.2011.61.12.5.

vii. Nelson, N. C., Erwin, S. O., and Schmidt, J. C. 2013. Spatial and temporal patterns in channel change on the Snake River downstream from Jackson Lake dam, Wyoming. *Geomorphology* 200:132-142. doi.org/10.1016/j.geomorph.2013.03.019.

viii. Olden, J. D., Konrad, C. P., Melis, T. S., Kennard, M. J., Freeman, M. C., Mims, M. C., Bray, E. N., Gido, K. B., Hemphill, N. P. Lytle, D. A., McMullen, L. A., Pyron, M., Robinson, C. T., Schmidt, J. C., and Williams, J. G. 2014. Are large-scale flow experiments informing the science and management of freshwater ecosystems? *Frontiers in Ecology and the Environment* 12: 176–185. http://dx.doi.org/10.1890/130076.

(4) *National Handbook on Stream Restoration Decision Analysis and Design Guidance.* This project was a collaboration among ICRRR, the National Center for Earth-surface Dynamics (NCED, an NSF-supported

Science and Technology Center), and the U.S. Army Corps of Engineers (USACE) Engineering and Research Development Center. The project provided decision analysis and design support for an objectives-driven predictive approach to stream restoration. The approach focuses on well-defined stream objectives, including channel stability, infrastructure protection, water quality improvement, including nutrient and sediment loading, fish passage, aquatic species recovery, and aesthetic/recreation enhancements. In the first year of the project, salary support was provided from NCED for a post-doctoral researcher who managed the project. DoE funds were used in the second year of the project to provide salary for the project manager and one month of salary support for Peter Wilcock, who directed the project. After the second year of the project, ongoing support for the post-doctoral project manager was provided by USACE.

The project developed a web-based decision support system that led to a Multi-Criteria Decision Analysis tool for assessing and developing stream restoration projects. The tool was presented in workshops across the country and was then used as a core technology for a USACE initiative to develop stream restoration decision support for urban steams, within the broader USACE Environmental Benefits Analysis program (http://cw-environment.usace.army.mil/eba/index.cfm)

a. *Key Workshops:*

Mid-Atlantic Stream Restoration Conference, Flintstone, MD – Nov 2011
River Restoration Northwest, Stevenson, WA – Jan 2012
Upper Midwest Stream Restoration Symposium, Oconomowoc, WI – Feb 2012
World Environmental & Water Resources Congress (EWRI-ASCE), Albuquerque, NM – May 2012
Stream Restoration in the Southeast, Wilmington, NC – Nov 2012

b. Publications:

Niezgoda, S. L., P. R. Wilcock, D. W. Baker, J. M. Price, J. M. Castro, J. C. C. T. Wynn-Thompson, J. S. Schwartz and F. D. Shields, Jr. 2014. Defining a stream restoration body of knowledge as a basis for national certification. *Journal of Hydraulic Engineering*.140(2), 123-36. doi: 10.1061/(ASCE)HY.1943-7900.0000814

Laub, B. G., Baker., D. W., Palmer, M. A. and Bledsoe, B. P. 2012. Range of variability of channel complexity in urban, restored and forested reference streams. *Freshwater Biology* 57(5), 1076–1095. doi:10.1111/j.1365-2427.2012.02763.x.

5) *Investment in junior faculty in the Watershed Sciences Department*

a. Belmont Hydrology and Fine Sediment Lab:

The ICRRR played an important role in the establishment of the Belmont Hydrology and Fine Sediment Lab at Utah State University. The ICRRR contributed 50% of funds needed to purchase a Teledyne RD Instruments River Ray Acoustic Doppler Current Profiler as part of Belmont's startup package. This instrument has been used extensively for research and educational purposes for measuring stream flow and mapping river bathymetry, including more than 180 km of the Minnesota River. Further, the instrument has been used in three courses, Small Watershed Hydrology (WATS 4490/6490), Watershed Sciences Graduate Induction Course (WATS 6260), and Sediment Transport in Stream Assessment and Design as a state-of-the-art demonstration for measuring streamflow velocity, discharge and bathymetry.

The ICRRR also provided support for two key personnel in the Belmont Lab. ICRRR provided a third of funds needed to support post-doctoral research associate Barbra Utley for two years. Barbra played an important role in the Belmont Lab in development of educational materials and research materials that ultimately led to development of a successful proposal for a $4.6M research grant

from the National Science Foundation. After her post-doc, Dr. Utley moved on to a career with Campbell Scientific. In addition, the ICRRR provided half of the funds needed to support MS student Justin Stout in the Belmont Lab. As Dr. Belmont's first graduate student, Justin played an important role in establishing the lab. His MS resulted in two peer-reviewed publications and he subsequently went on to complete a PhD at University of Melbourne and currently serves as a post-doctoral research associate at the Australian Rivers Institute.

b. Wheaton Ecogeomorphology and Topographic Analysis (ETAl) Lab:

The ICRRR played a large role in providing a foundation for the development of the ETAl lab and the associated Eco Logical Research Lab that together comprise the Fluvial Habitats Center (FHC). This center supplanted many ICRRR activities, and many of the research foci of the FHC and the agency collaborations maintained by the FHC were originally based on partnerships established by the Watershed Sciences Department and the ICRRR.

C. Staffing

Jack Schmidt, Utah State University, served as director of the ICRRR from its inception until summer 2011. During that time, co-directors were Peter Wilcock of The Johns Hopkins University and Phaedra Budy, assistant leader of the USGS-BRD Utah Cooperative Fish and Wildlife Research Unit (UCFWRU). In August 2011, Schmidt took leave from Utah State University and was hired as Chief of the U. S. Geological Survey Grand Canyon Monitoring and Research Center. Thereafter, Budy served as ICRRR director. Joe Wheaton was a co-director after he joined the Utah State faculty. Schmidt earned $36,000 in summer salary distributed among FY 2007/2011/2012.

Wheaton earned $27,000 in summer salary in FY2012. Budy did not receive compensation.

D. Post-doctoral Research Fellows and Graduate Students Supported by the ICRRR

The following post-doctoral research fellows were supported by the ICRRR:

- Mary Conner (FY2012; $3000)
- Nicole Czarnomski (FY2012; $36,000)
- Scott Miller (FY2008/2009; $52,000)
- Erich Mueller (FY2012/2013; $1,000)
- Nira Salant (FY2009/2010/2011; $52,000)
- William Saunders (FY2012; $8,000)
- Barb Utley (FY2010/2011; $28,000)

The following graduate students were partly supported by the ICRRR. Most of these graduate students successfully completed their graduate degrees in speciality areas of stream restoration or large river rehabilitation:

- Marshall Baille/MS (FY2009; $3,000)
- Nathaniel Bergman/MS-dnf (FY2010; $8,000)
- Susannah Erwin/PhD (FY2010/2011; $4,000)
- Stephen Fortney/MS (FY2011/2012; $19,000)
- Alan Kasprak/PhD (FY2011; $11,000)
- Stephen Klobucar/PhD (FY2012; $3,000)
- Katrina Langenderfer/MS-dnf (FY2009; 9,000)
- Rebecca Manners/PhD (FY2011/2012; $9,000)
- Justin Stout/MS (FY2012; $13,000)

E. Acquisition of Capital Equipment

Earmark funding facilitated capitalization of research activities in the Department of Watershed Sciences. This equipment included pickup trucks, survey equipment, stream-flow measurement equipment, and sediment measurement equipment.

Vehicles –
Ford F250 pickup truck ($24,000)
Ford F150 pickup truck ($8,000)

Survey equipment –
Leica Geosystem ($30,000)
GS15 Basic, RTK GNSS SmartAntenna Geodetic ($36,000) [Wheaton lab]
3” Robotic Total Station & Accessories ($22,000) [Wheaton lab]
GNSS RTK Rover/Base Station Demo-6515 & Accessories ($18,000) [Wheaton lab]
GNSS RIC Rover/Base Station 6515 & Accessories ($13,000) [Wheaton lab]
NIKON Instrument Group ($23,000) [Wheaton lab}

Stream-flow measurement equipment –
River ADCP ($13,000) [Belmont lab]

Sediment measurement equipment –
LISST Particle Size Analyzer ($18,000) [Belmont Lab]

F. Subcontracts to Other Institutions

The only major subcontract supported by this earmark was to The Johns Hopkins University (FY 2012 and 2013). $104,000 was directed to provide partial salary of Dan Baker, post-doctoral research associate, and supplemental salary was paid to Peter Wilcock.

G. ICRRR -- Extramural Funding Record

The earmark awards were critical in advancing the entire program in river restoration and rehabilitation in the Watershed Sciences Department. The earmark grants provided a foundation of infrastructure and base support that was leveraged to gain other funding, especially from federal and state agencies. Approximately $3,200,000 was brought into the ICRRR by Schmidt and Budy between 2006 and 2011 on projects directly related to the work of the ICRRR.

Large River Rehabilitation (Schmidt)

Big Bend restoration (Rio Grande)	NPS	$119,000
Glen Canyon Dam (Colorado River)	USGS	$891,000
San Rafael River restoration	NRCS	$105,000
Dinosaur Monument (Green/Yampa Rivers)	NPS	$81,000
Walker River (NV) restoration	USFWS	$125,000
Snake River {WY) management	NPS/USGS	$95,000

Stream Restoration and Fisheries Management (Budy)

Factors affecting trout populations (Logan River)	Utah DWR/USFS/USU	$594,000
Bull trout recovery	USFWS	$847,000
San Rafael River endangered fishery	BoR	$30,000
Whirling disease threats	USGS	$196,000

Small Stream Restoration and Project performance (Miller, post-doctoral research associate)

Grazing exclosures as a restoration tool	Utah DWR/USU	$62,000
Effects of irrigation diversions	USFS	$46,000
Restoration project data base	Utah DWR	$12,000