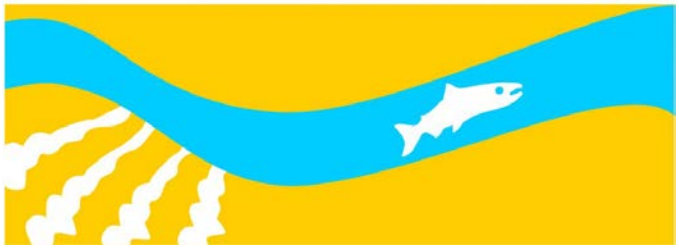
Study 22

USGS San Joaquin River Tributary Sediment and Geomorphology Study

Public Draft
2014 Monitoring and Analysis Plan

SAN JOAQUIN RIVER
RESTORATION PROGRAM



September 2013

1. Sediment Monitoring and Surrogate Analyses, FY13

The primary research objective of this study is to quantify the rate, timing, and grain size distribution of sediment entering the mainstem San Joaquin from Little Dry Creek and Cottonwood Creek. Potential sediment continuity issues in the tributaries (e.g. capture by gravel pits) as well as the mainstem (e.g. deltas at tributary mouths) will also be examined.

1.1. Quantify the Topography of the Tributaries

To quantify the topography of the tributaries immediately upstream of their confluence with the San Joaquin River as well as their deltas, a combination of Terrestrial Laser Scanning and topographic surveys (including monumented cross sections) will be performed. At a minimum, the tributary stream topography within 200 m of the confluence, and at least 100 m upstream and downstream along the mainstem San Joaquin will be surveyed with Terrestrial Laser Scanning. The Terrestrial Laser Scanning and cross section datasets will be used to estimate delta volumes, as inputs into bedload and total load calculations, and as a baseline dataset for future studies and monitoring by SJRRP. Historical aerial photography at the tributary confluences (already collected and rectified by Reclamation) will be used to evaluate historical changes in the tributaries and their deltas near the confluences.

1.2. Geomorphic Evaluation of the Tributaries

A geomorphic analysis of the tributaries upstream of their confluences with the San Joaquin River will be conducted utilizing field surveys, the 2008 aerial LiDAR flight, geomorphic mapping, and measurements of grain size distributions. The aerial LiDAR data collected in the 2008 flight covers the lower reaches of both tributaries (Elaina Gordon, Reclamation, pers. comm. 1/10/2011). A recent reconnaissance trip to the lower reaches of Little Dry Creek during a moderate flow event (approximately 100 cfs) indicated that at least two of the abandoned gravel pits were nearly full of sediment, such that sediment was passing freely through this reach. Sediment supply to the lower reaches of Little Dry Creek, downstream of the discharge weir at the North Friant Road Bridge, will be estimated using calculations of bedload and total load, as well as the sediment basin dredging records from the Fresno Metropolitan Flood Control District (Paul Allen, FMFCD, pers. comm. 1/21/2011).

1.3. Monitoring of Sand and Coarse Sediment Transport in the Tributaries

Sand and coarse sediment transport will be sampled with several Bunte-type samplers (Bunte et al. 2007), which will work well on these flashy tributaries, as they can be deployed for lengthy periods of time (up to several days) and do not require active human presence. Potential sites for the Bunte samplers include the tributaries immediately upstream of their confluences with the San Joaquin, as well as the discharge weir on Little Dry Creek at the North Friant Road Bridge.

This study covers three years, WY2011-2013. Sediment samplers will be deployed during the winter wet season in all three years. Data analysis and transport calculations will occur in the summer and fall of each year following the winter/spring field work.

Deliverable: A final report will be prepared documenting the study results following the third year of field work (due Sep 30, 2013). Information and presentations will be provided to SJRRP staff on an ongoing basis that will be timed to provide adequate information for flow release planning for each water year.

1. Project Management for USGS Support of SJRRP, FY13

This modification provides funding to support project management for FY2013 funded activities.

Project management provides explicit funding to track and report on tasks and maintain tight linkages to the goals of the Restoration Program. Duties include reading and review of SJRRP documents, coordinating work between the tasks, and attendance at meetings to identify potential coordination areas.

2. San Joaquin Sediment Monitoring, FY13

This modification provides FY2013 funding for USGS suspended sediment and bedload sampling at 6 sites (one site added for FY12). Each site will be sampled every other week by the USGS for a period of 16 weeks starting approximately February 2013 and ending approximately June 2013. Each USGS crew will spend one full day at each of the sampling sites, collecting one set of suspended sediment samples, one bedload sample, one bed material sample, and making at least one streamflow measurement. All sampling is to be conducted using standard USGS sampling protocol. Suspended sediment samples collected by USGS will be analyzed for sand/fine split.

Five sampling sites have been selected by Reclamation for USGS sampling; an additional site (6) is being investigated by USGS for inclusion during FY13:

1-SJR at HW 41	11252275
2-SJR nr Skaggs Bridge	11252975
3-SJR at Gravelly Ford	11253058
4-SJR below Chowchilla Cn Intake (bifurcation)	11253115
5-SJR nr Mendota	11254000
6-SJR to be located above mile 219 and below Gravelly Ford	

Schedule: every other week for a period of 16 weeks starting approximately February 2013 and ending approximately June 2013.

Deliverable: web-hosted data on USGS NWIS interfaces.

3. Seepage Management, FY13

The USGS role in the seepage management component of the SJRRP focuses on supporting the continued development of a Seepage Management Plan. If FY13, the emphasis is on development, calibration, and documentation of groundwater flow models in support of multiple aspects of the Plan. Other tasks include continued development and maintenance of a groundwater database and associated products, and technical support on SJRRP-related groundwater issues, including evaluation of data associated with damage claims.

3.1. Data

Continue water-level database maintenance & development

1) determine well construction, etc., and update with recent data

2) migrate into Access database for improved stability & query capabilities

Deliverable – included in model report and seepage management plan

3.2. Data Analysis

1) complete maps of depth to the water table and water-table elevation

2) document these maps in Seepage Management Plan

3) continue analysis of hydrographs & maps in support of modeling, monitoring threshold analysis, etc

Deliverable – included in model report and seepage management plan

3.3. Evaluation of Sand Stringers

In FY12, the USGS and Reclamation evaluated the efficacy of using geophysical methods—frequency-domain electromagnetic induction (FEM) and electrical resistivity tomography (ERT)—to identify abandoned channels, or sand stringers, that may act as conduits for river seepage into fields. The presence of such conduits in a field may substantially increase the susceptibility of crops in that field to seepage impacts from Interim and Restoration Flows. Understanding the geometry and hydrogeologic characteristics of the sand stringers, which may vary greatly, is essential for determining appropriate engineering solutions for seepage mitigation, which may include slurry walls to cut off the sand stringers and/or installing shallow wells or sumps and using the stringers as drains.

Three parcels along reaches 3 and 4 of the river were investigated during FY12. Results from the geophysical work, which were ground-truthed using shallow (5 ft) hand-auger borings, showed strong correlations between sandy soils, high resistivity in ERT data and low conductivity in FEM data. These methods were very effective for detecting and measuring the geometry of sand stringers, and allow for more detailed subsurface geological exploration than is possible using point borings. The combination of geologic interpretation from point borings and geophysical data has resulted in improved understanding of the subsurface.

For FY13, Reclamation is investigating up to 9 parcels along the river in the areas that have experienced seepage effects during Interim flows (reaches 3-4). The USGS will, in tandem, apply the geophysical methods to identify and measure sand stringers as data needs and budget constraints allow. Because of the relative ease of collecting FEM data, this low-cost method will be used to identify locations and approximate size of sand stringers; for a subset of channels, ERT will be used to determine the detailed channel geometry.

Once identified, a subset of sand stringers will be monitored using one or more methods to quantify seepage rates in these channels, thereby determining the potential effectiveness of engineering solutions. A shallow well or wells will be installed by Reclamation in a subset of stringers, using CPT or hollow-stem auger methods, for the purposes of confirming the channel depth and conducting hydrologic monitoring. Potential methods for determining seepage rates through these channels include:

- Salinity and other natural tracers
- Analysis of distributed temperature data (heat flow simulation)
- Measured hydraulic gradients coupled with hydraulic properties tests
- Groundwater velocity meters (not a straightforward application)

The feasibility and cost effectiveness of these methods will be evaluated at one or more sites, and additional sites will be monitored using the most cost-effective method(s). The proposed budget is designed to address 4-7 parcels.

A priority will be to select and instrument one or more sand stringers prior to the spring Interim Flows, which may begin ~March 1, 2013. This will be a good opportunity to test multiple methods for determining seepage rates through these channels. To accomplish this, stringers identified during FY12 on the Willis and Iest parcels, for which various permits and access agreements exist, may be selected for instrumentation.

Deliverable – On-line Open File Report to document analyses. Results will be included in Seepage Management Plan.

3.4. Local Grid Refinement Tool and Farm Process

The Central Valley Hydrologic Model (CVHM) uses the Farm Process (FMP) to simulate irrigated agriculture within MODFLOW. The modeling efforts described below include refined-scale models within the CVHM model grid. The Local Grid Refinement (LGR) MODFLOW package enables fully embedded “child” models within CVHM. However, LGR and FMP did not work together; during FY11-12, the code was developed to support local grid refinement in models using FMP.

Deliverable - Completion of the code documentation and applications will occur during FY13.

3.5. Modeling

The preliminary ¼-mile-scale model (SJRRPGW) was developed during FY11-12 for the 5-mile buffer zone along the 150-mile SJRRP reach of the San Joaquin River. SJRRPGW is temporarily linked via head and flux-based boundaries to the CVHM, and ends in 2003. The first priority in FY13 is to publish documentation of the preliminary SJRRPGW to support near-term efforts. The second priority is the temporal extension of the model from 2003 to present and other enhancements, described below, to support longer-term efforts.

Enhancements will be made to SJRRPGW during FY13 in order to (1) improve its ability to accurately simulate river flows and seepage, other stresses, and aquifer-system response; and (2) evaluate uncertainty associated with simulated seepage. These enhancements include:

- temporal extension from 2003 (end of CVHM) to current, allowing for calibration to Interim Restoration Flows, and thus more accurate simulation of Restoration flows and associated responses [ongoing extension of CVHM by another project will allow for updated boundary conditions]

- consideration of multiple equally probable TProGS-generated sediment texture models to determine sensitivity of SJRRPGW results to the texture distribution, and to seek the best fit

- apply existing methods within the parameter estimation software (PEST) to evaluate the uncertainty of simulated seepage

- embed the SJRRPGW within CVHM using MODFLOW FMP-LGR, as described above, thereby providing improved boundary conditions and simultaneous run capabilities, which are important for scenario development

- incorporate climate variability and change into future scenarios, which is important for evaluating the robustness of monitoring thresholds and various response actions

- > land subsidence, which is an important issue for the SJRRP with respect to construction design, exacerbation of drainage issues, and effects on river stage, can be modeled within this model. It is addressed as a separate component of USGS involvement in the SJRRP.

The updated SJRRPGW will be documented in a USGS report and used for future analyses. It will also be used to provide boundary conditions for **finer-scale models** to be used for closer examination of near-river processes/issues, including:

1) estimation of spatial & temporal distribution of groundwater/surface-water interactions and associated seepage losses

2) evaluation of local issues, including landowner damage claims (see below)

Applications of the SJRRPGW and associated finer-scale models may include:

- evaluation of the monitoring corridor – how far away from the river should water-level monitoring occur?

- support of Reach-specific studies, including Reaches 2 & 4

- areal & temporal evaluation of monitoring thresholds

  - simulate range of hydrologic conditions over long periods
  - evaluate overall effectiveness of monitoring thresholds
  - evaluate those conditions for which exceedance of monitoring thresholds that are outside the Restoration activities, but can cause impacts (e.g., wet years, subsidence, irrigation.)
  - consider temporal adjustments in thresholds for more robust performance, perhaps based on climatic factors and antecedent conditions

- comparison of alternative physical SJRRP response actions, including:
  - projects – slurry walls, drains, wells, etc.
  - flow management – adjust releases, flow routing, etc.
- other Seepage Management Plan support

Deliverable – The updated SJRRPGW will be documented in a USGS report and used for future analyses.

3.6. Subsidence Estimation Modeling for Project Construction Design

Surveys indicate that during 2008–10 a large, continuous subsidence area extending about 60 miles east-west by 20 miles north-south has, in places, subsided at among the largest rates historically measured in the San Joaquin Valley. The area of maximum subsidence, 1.73 feet (annual rate of almost 0.9 ft/yr), occurred adjacent to the Eastside Bypass. Unpublished GPS surveys conducted during 2011–12 by BOR indicate the continuation of high rates of subsidence in the region. This land subsidence feature affects Reaches 3-5 of the San Joaquin River and the adjacent bypass system.

Local effects of differential subsidence include reduced freeboard and flow capacity of the Delta-Mendota Canal, the California Aqueduct, the San Joaquin River, the Eastside and other Bypasses, and other canals that deliver irrigation water and transport floodwater. Also affected are dams and other flow control structures.

The SJRRP currently is working on the construction design for the near-future replacement of Sack Dam, which diverts water from the San Joaquin River to the Arroyo Canal for irrigation purposes by exchange contractors. The future rate of subsidence during the intended lifespan of the new Sack Dam (25 years) is unknown, but is critical to the design and associated cost and longevity of the structure.

The objective of this Task is to estimate future subsidence in the SJRRP region over the next 25 years to aid in construction design. The model simulation will be based on current knowledge of the groundwater flow system and new data on subsidence

distribution and magnitude, well construction, pumping distribution, the distribution and thickness of fine-grained compactable materials, and other information.

This work will dovetail with Task 3.5, Modeling, involving the refinement and updating of the USGS Central Valley Hydrologic Model (CVHM) to simulate subsidence along the Delta-Mendota Canal. The focus of Task 3.5 is on the area west of the San Joaquin River; this new Task will expand the scope eastward to include the Sack Dam, the bypass system, and surrounding areas within 5-7 miles of the river.

Updates to the CVHM will include:

- refinements in well construction
- refined distribution of surface-water deliveries and groundwater pumping
- revised distribution and thickness of fine-grained materials (if needed, post-evaluation)
- potential zonation of compaction-related parameters on basis of depositional environment
- re-calibration of subsidence to results from Interferometric Synthetic Aperture Radar (InSAR) and GPS surveys

After calibration, a range of potential future hydrologic conditions will be simulated, resulting in a range of subsidence outcomes for consideration in construction design.

Deliverable – These updates to the CVHM and associated scenarios will be documented in a USGS report, either in conjunction with the report listed in Task 3.5, or in a tand alone report.

3.7. Seepage Management Plan support

1) incorporate modeling and other analyses into the Plan
2) stakeholder meeting attendance and support
3) continue to support SJRRP staff on groundwater matters, reviews, etc.
4) Technical support on local seepage issues – several damage claims were submitted during FY11-12. USGS provided technical support to Reclamation in several forms, including:

- evaluating site conditions
- suggesting locations for additional monitoring
- analytical modeling to estimate potential effects of increased river stage on water table at various distances from the river

- technical review of related documents

This task is anticipated to continue during FY13, possibly including the development of:

- small-scale, conceptually simple scoping models for the purpose of simulating field-scale phenomena, such as the potential that small near-surface paleochannels extend the lateral influence of seepage effects, and/or

- highly refined embedded models for similar purposes

4. Sediment Monitoring and Surrogate Analyses, FY13

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4.1. Quantify the Topography of the Tributaries

To quantify the topography of the tributaries immediately upstream of their confluence with the San Joaquin River as well as their deltas, a combination of Terrestrial Laser Scanning and topographic surveys (including monumented cross sections) will be performed. At a minimum, the tributary stream topography within 200 m of the confluence, and at least 100 m upstream and downstream along the mainstem San Joaquin will be surveyed with Terrestrial Laser Scanning. The Terrestrial Laser Scanning and cross section datasets will be used to estimate delta volumes, as inputs into bedload and total load calculations, and as a baseline dataset for future studies and monitoring by SJRRP. Historical aerial photography at the tributary confluences (already collected and rectified by Reclamation) will be used to evaluate historical changes in the tributaries and their deltas near the confluences.

4.2. Geomorphic Evaluation of the Tributaries

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4.3. Monitoring of Sand and Coarse Sediment Transport in the Tributaries

Sand and coarse sediment transport will be sampled with several Bunte-type samplers (Bunte et al. 2007), which will work well on these flashy tributaries, as they can be deployed for lengthy periods of time (up to several days) and do not require active human presence. Potential sites for the Bunte samplers include the tributaries immediately upstream of their confluences with the San Joaquin, as well as the discharge weir on Little Dry Creek at the North Friant Road Bridge.

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Deliverable: A final report will be prepared documenting the study results following the third year of field work (due Sep 30, 2013). Information and presentations will be provided to SJRRP staff on an ongoing basis that will be timed to provide adequate information for flow release planning for each water year.

4.4. Measurement of Bedload Sediment Transport by Hydrophones

A total of nine hydrophone stations will be deployed and evaluated on the San Joaquin River for water years 2013 and 2014. Eight of the stations will be located in the reach of interest from Friant Dam down to the Highway 41 Bridge. Five calibrated or semi-calibrated hydrophone installations will be used to quantify sediment transport rates and to estimate bed mobilization and cessation, four un-calibrated hydrophones will be used to estimate bed mobilization and cessation. All but one of the hydrophone stations will be stereo hydrophone installations (e.g. two recording heads) to help minimize potential issues with head placement and the proximity to zones of bedload movement. The one remaining installation will be a “Quadraphone” station, consisting of two stereo hydrophone installations (e.g. two x two recording heads) to investigate full across-channel bedload sediment transport and will be used to investigate the possibility of mapping particle impacts to locate zones of bedload transport in the stream.

The locations of the hydrophone installations are as follows. Two calibrated stereo hydrophone installations will be located on the mainstem San Joaquin River at existing bedload sampling locations, Ledger Island and Skaggs Bridge. Though Skaggs Bridge is outside the primary reach of interest, it is a gravel-bedded site and it is the next closest physical bedload sampling site, which will be needed for testing purposes. Another calibrated hydrophone station, the ‘Quadraphone’ station, will be co-located with the physical bedload sampling station at Highway 41.

Two semi-calibrated stereo hydrophone installations will be located on the two major tributaries, Cottonwood Creek and Little Dry Creek. Both Little Dry Creek and Cottonwood Creek have no water for the majority of the year but when floods occur, there is a high likelihood of transporting large volumes of coarse bedload into the mainstem San Joaquin River. The physical bedload sampling data for calibration at the

two tributaries will be provided from an existing tributary sediment study by the authors that will be active through WY2013. If necessary, additional bedload sampling will be collected in WY2014 to calibrate the hydrophones as part of the present proposal.

In addition to the calibrated stereo hydrophone stations, four un-calibrated stereo hydrophone stations will be installed at locations between Friant Dam and the Highway 41 Bridge to evaluate the estimation of the threshold of mobilization for coarse bedload particles as well as cessation of transport. Two locations will be in the proximity of Riffle Clusters 38 and 40, which already have SJRRP mobilization studies occurring on them using painted rocks and radio transmitters (SJRRP 2011). Two other un-calibrated stereo hydrophone sites will be placed following input from SJRRP staff to determine locations most of interest.

The audio data will be processed using methods developed previously by Marineau *et al.* (2012). Where physical bedload samples are collected, the mean acoustic intensity will be calibrated using the measured bedload transport rates. If sites are located where physical bedload samples are not collected (e.g. riffle sites), the audio data will be used to qualitatively assess if coarse bedload movement occurred and will be used to identify the timing of the start and stop of bedload movement.

To assess the possibility of using the 'Quadraphone' station to geo-spatially locate bedload movement, the location of each hydrophone receiver will be surveyed by RTK GPS or total station. Also a general survey of the nearby bed topography will be performed. To calibrate the timing of the hydrophones relative to the spatial location, a pipe or other sound-generator (e.g. artificial rock impacts) will be used with time-of-travel techniques to determine the geo-spatial location of the sound source.

Deliverables: Results will be presented to the SJRRP Sediment Work Group. It will also be documented in a peer reviewed journal and presented at a national conference to maximize the breadth of review for.

4.5. Evaluation of sediment transport measurements and performance of transport equations

Three years of existing sediment transport measurements (WY2010-2012) at the six sediment sampling sites on the San Joaquin River have not yet been evaluated. In the task, USGS will evaluate measured sediment transport and compare it to empirical sediment transport equations and site-specific conditions, such as hydraulics, bed grain size, and topography. USGS will evaluate previously-constructed 2D hydraulic models that contain the bedload sampling sites, as well as ADCP measurements taken at the time of sampling, if applicable. The project will require no additional field work or data collection. This study will occur in conjunction with a related study evaluating the existing USGS sediment sampling sites and estimating a sediment budget that will be performed by Bureau of Reclamation Technical Science Center staff. The results will be presented to the SJRRP at a work group or annual meeting, as well as a report (either a journal article or technical memo).

5. Fish Management Plan Support

The Restoration Goal of the San Joaquin River Restoration Program includes reintroduction of Chinook salmon to the San Joaquin River below Friant Dam. A secondary objective is to establish healthy populations of other native fishes. Meeting these objectives requires a variety of activities including preparation, review, and revision of planning documents, gathering and synthesis of background material, design of monitoring programs and studies, and synthesis and interpretation of monitoring and study results. The need for these individual tasks will change as the project proceeds. The following subtasks are applicable through the completion date of this agreement of 31 December 2014. The following subtasks and deliverables may be modified as needed by Reclamation and USGS, in coordination with USFWS.

5.1. Assessment of Water Quality Data with Respect to Fish

Evaluate water quality data collected by USBR with respect to established criteria for Chinook salmon. The report will include a summary of the water quality data available and a summary of the available criteria for the protection of fishes. The general schedule for ATR contributions is a draft to the Workgroup in February and a final version for public review in March. More specific dates will be assigned in consultation with the FMWG as needed.

Deliverables:

1) Updated or new sections of the ATR, Monitoring and Analysis Plan or other plans and reports as appropriate.

2) USGS OFR

5.2. Non-Structural Fish Passage

Evaluate various model outputs to identify areas of shallow, high velocity water that may impede upstream or downstream migration of juvenile or adult fishes, specifically Chinook salmon. Conduct field studies as needed to verify problem areas.

Deliverables: Updated or new sections of the ATR, Monitoring and Analysis Plan or other plans and reports as appropriate.

5.3. Fish passage Design Criteria Technical Memorandum

The Fish Passage Design Criteria Technical Memoranda (TM) describes the upstream fish passage strategy for the San Joaquin River Restoration Program (SJRRP) for the purpose of guiding engineering modification to structures within the San Joaquin River and flood bypass between Friant Dam and the Merced River confluence. The designs for river and bypass facilities will seek to provide unimpaired passage through the bays of facilities during spring pulse releases. The site-specific projects identify modifications to river facilities to provide upstream passage for Chinook salmon and other fish. The engineering design to modify facilities requires identifying the type of structure and the hydraulic performance for each facility on the river and bypass. Ladders or ramps may use different criteria than the bays of a structure and, in some cases, meeting passage

criteria may require multiple ladders, ramps, or bays. Work on the site-specific studies identified species of concern and the hydraulic criteria for passing species. This TM documents the hydraulic criteria and develops the following information to support a recommendation on fish passage design criteria:

1) Species of Concern: fish species under consideration with the Restoration Area;

2) Design Parameters: engineering criteria for the structural in order to pass fish;

3) Fish Migration Biology: biological migration needs of species at different stages in their life cycle including:

    a. Geographic Extent: area requiring access,

    b. Timing: when fish may need to migrate into the different areas within a year, and

    c. Passage Frequency: how often fish require migration to support a population, e.g. every year, every other year, etc.; and

4) Structural Options (including Costs): what types of facilities can be built.

5) Additional Considerations: other aspects of design that will improve passage beyond hydraulic criteria.

USGS will primarily assist with item 3 by conducting a literature search and analyzing existing data.

Deliverables: The deliverable is a SJRRP technical memorandum of which USGS will contribute part. The current schedule is to complete the memo in FY13. The final schedule will depend on USFWS, which is leading this effort.

5.4. Participation in Fish Work Group

The Fish Management Work Group (FMWG), led by the USFWS, is the lead group for fisheries related activities within the SJRRP. USGS will participate in regular meetings to keep informed about ongoing projects and new issues and to keep the FMWG informed of USGS progress on assigned tasks.

Deliverables: Participation in regular FMWT meetings and other meetings as necessary.

5.5. Scientific publication (Larry and Marissa):

The San Joaquin River Restoration Program represents a substantial effort to re-establish a functioning river. Thus, it is tremendous interest to a variety of groups ranging from scientists to the public. As a substantial investment in river restoration the results of the effort should be made widely available to other scientists and managers.

Deliverables: Articles for publication in scientific journals and other outlets as appropriate topics are identified. Presentations at scientific meetings as appropriate topics are identified.