Study 47

Spring Run Spawning Habitat Assessment – Sediment Mobility

Final
2014 Monitoring and Analysis Plan

SAN JOAQUIN RIVER
RESTORATION PROGRAM

November 2013

San Joaquin River Restoration Program

2014 Monitoring and Analysis Plan

Reach 1A Spawning Habitat Assessment – Sediment Mobility Component

1. Statement of Need

The San Joaquin River Restoration Program (SJRRP) Restoration Goal is to "restore and maintain fish populations in good condition in the main stem of the San Joaquin River below Friant Dam to the confluence of the Merced River, including naturally-reproducing and self-sustaining populations of salmon and other fish." The SJRRP Fisheries Management Plan (SJRRP 2010) identifies spawning and incubation as a life stage to be supported for successful completion of the salmon life cycle. The SJRRP Spawning and Incubation Group agreed on a process for ensuring adequate spawning habitat is available to support fish populations, and a central effort in that process involves identifying the quality and quantity of spawning habitat. Several uncertainties exist as to the suitability for successful spawning in the existing stream bed within Reach 1A, which include adequate (1) hyporheic and surface water exchange, (2) flow depth and velocity, (3) sediment attributes, and (4) hyporheic water quality. The channel area that currently contain and is expected to maintain each of these attributes in high quality should be used to quantify the amount of suitable spawning habitat.

2. Background

The completion of Friant Dam in the 1940s resulted in a coarsened bed texture downstream. However, in addition to bed erosion, other processes such as erosion of stored bank deposits and floodplains, and fine sediment contributions during tributary flow events have, to some extent, maintained a supply of mobile sand in Reach 1A. It is generally accepted that the proportion of fine sediment (e.g. sand and finer) is inversely related to egg survival.

Multiple studies are currently underway or have been completed to help identify the quality of the hyporheic environment as it relates to successful spawning, incubation, and fry emergence (see SJRRP 2013). These include efforts to evaluate water quality within the hyporheic zone (DO, water temperature, fine sediment accumulation), egg survival, spawning habitat use by trapped-and-hauled fall-run Chinook, bed material size and mobility, scour and deposition, and channel morphology changes associated with alteration to the flow regime. Recently, the USBR has proposed quantifying the spawnable area based on a layered approach of the above compilation of characteristics (see USBR 2013).

In 2009, DWR began a study designed to evaluate bed mobility within Reach 1A at two riffles approximately midway between Friant Dam and Highway 41. The result of this study is a measured and validated critical shear stress (Shield's numbers of 0.033 and 0.028 at Riffle 38 and 40, respectively) for incipient entrainment of coarse bed material (i.e. gravel and cobble). With this primary input parameter for sediment transport formulae, the sediment transport rate for specified discharges can be predicted and, aided by a two dimensional (2D) hydraulic model, the area of mobilization can be delineated and quantified. Additional information is gained from transport distance and storage loci of mobilized particles. These characteristics can be used to determine continuity of transport within the geomorphic unit (i.e. from bar to bar) or the lack thereof. Understanding this process will inform the Program of gravel replenishment to spawning loci, degradation of pools by sediment filling, and channel adjustment under the adjusted flow regime.

Between 2008 and 2011, Tetra Tech (2011) assessed sand storage and sources within Reach 1A. The amount of sand within the channel and the location of other sources are useful for understanding which areas are more susceptible to deposition. Sand transported on the bed surface is much more likely to deposit between larger particles where it is sheltered from the force exerted by the flowing water. Such transport and resulting deposition can clog gravel interstices, reducing hyporheic ventilation, as observed during the egg survival/sand accumulation study. Several sand source areas were noted in Tetra Tech (2012), including eroding banks, bluffs, floodplain, and side channels. However, flows capable of accessing and eroding these storage sites are not known, and therefore, the change in sand storage and the rate of contribution to the channel from these sources are also presently unknown.

In 2011, DWR began a spawning gravel sand accumulation study in collaboration with the USFWS egg survival study. Results indicate variable egg survival that correlates well with sand accumulation. Sand transport was observed to vary across the five study sites, which were evenly spaced between Friant Dam and Highway 41. The upstream-most site (at RM 266.7) experienced the least sediment transport and deposition, while these attributes generally increased with distance downstream. The greatest transport and deposition occurred at the fourth site downstream (RM 258.6). Transport and deposition of sand decreased at the fifth site (RM 255.5) relative to the fourth site. These results suggest local sources supplying sand, a translating sand pulse, and/or differential sand storage within the channel and are supported by sand mapping efforts by Tetra Tech (2011) and bed sample results collected by DWR (SJRRP 2012). Furthermore, the amount of sand being transported and deposited within the artificial redds is sufficient to inhibit egg survival.

In 2012, the USGS began monitoring the contribution of sediment provided by two intermittent tributaries within upper Reach 1A called Cottonwood Creek and Little Dry Creek. Though little, if any, coarse sediment is likely being supplied by these ephemeral streams, it is quite possible that they are providing sand-sized sediment to the main-stem San Joaquin River. Future monitoring results will provide information to quantify their contribution.

3. Anticipated Outcomes

The objective will be to characterize gravel and sand mobility in potential spawning habitat, and to map mobility characteristics at each site. These maps will be used as layers that will be joined with other habitat characterizing efforts to provide a habitat suitability index (HSI) throughout the Spring-run salmon spawning habitat. With the HSI maps the amount of spawning habitat deemed to fall within suitable characteristics will be delineated, quantified, and compared to the Project's goals. In addition, the mobility characteristics will be used to consider methods of expanding spawning habitat through enhancement strategies if it determined that there is a deficit in spawning habitat.

4. Methods

The following is a list of tasks necessary to achieve the goals and objectives of this scope:

1. **Plan data collection effort**.
    a. DWR will collaborate with fisheries scientists to identify primary spring run spawning locations at which to focus data collection efforts. The SJRRP SRH-2D calibrated hydraulic model output will be used to delineate areas with suitable flow velocity and depth at anticipated spawning season flows. Suitable areas will be targeted for each of the proposed investigations (i.e. gravel mobility and sand transport rates). As per discussions during the June 10, 2013 Spawning and Incubation Group meeting, USBR will provide the model output information.
    b. DWR will also assemble data collection plans that outline schedule and resource needs so that data collection assistance can be identified.
    c. Either the USBR or Tetra Tech will perform 2d hydraulic model runs to determine best sites for monitoring stations. The areas with the highest predicted shear stress will be delineated and the gravel mobility investigation will target these areas so as to monitor localized bed mobility during higher return interval flow events. In addition, channel traversing cross-sections will be selected upstream of the anticipated spawning habitat. These cross-sections will be used to monitor sand transport at anticipated managed flow releases. Ideally, they would also be accessible for bedload sampling equipment at nonwadable flow levels.
2. **Implement gravel mobility data collection effort**.
    a. DWR will deploy and survey RFID-tagged tracer particles to track their movement during pulse flows. Tracer placement at each site will bracket the areas anticipated to have the highest potential for transport at low return interval flow levels.
    b. DWR, with the assistance of other SJRRP agency personnel, will characterize the bed's surface texture in the vicinity of placed tracers. The bed's surface grain size

compositions are necessary for applying measurements of critical shear stress with respect to particle size and each size's proportion of the bed surface. This effort can be coordinated with USBR to supply information to the facies mapping.

c. DWR will perform a force gauge survey of particles larger than 32mm by selecting representative areas on each riffle and pool tail near tracer cross-sections to measure *in-situ* bed surface particles' resistance to motion.

d. DWR, with the assistance of other SJRRP agency personnel, will measure channel hydraulic characteristics at key flows using the following three techniques:

   i. Survey water surface elevation using a Real Time Kinematic (RTK) GPS with a vertical accuracy of approximately 2 cm. DWR will use this data to calibrate the 2D hydraulic model at the selected locations and observed flow levels.

   ii. Measure flow velocity and depth using an Acoustic Doppler Current Profiler (ADCP) along channel-spanning transects. DWR will use the measured water column depth and mean water column velocity to validate the calibrated hydraulic model's prediction.

   iii. Add additional pressure transducers to provide a continuous record of stage during the pulse flow release.

3. **Implement sand supply data collection effort.**

   a. Tetra Tech will survey sand supply from channel, bank, and floodplain sources to determine change in volume from previous measurements and to keep downstream sand transport measurements in the proper context of sand supply (i.e. bed material, pool, channel margin supply, or other). Two types of data collection will be needed:

      i. Tetra Tech will position stations for repeat channel spanning bedload measurements upstream of vulnerable spawning habitat as determined in 1.a. A hand-held Helley-Smith bedload sampler with a 0.125 mm mesh bag will be used to collect samples during the inclining limb of flow pulses at a range of wade-able flow levels. The USBR (see USBR 2013 Preliminary Sediment Budget Analysis of the San Joaquin, in press) proposes continued collection of bedload samples within the reach. Efforts will be made to coordinate with other agencies (USBR and USGS) for bedload sampling at flow levels that are nonwadable.

      ii. Bedload samples will be integrated at each location to determine the transport rate corresponding to the monitored flow. A sediment rating curve will be developed from the results at each site in the context of availability of sand for transport (i.e. upstream source is only bed material, pools and/or margins have an estimated volume of sand).

4. **Analyze data to determine relative habitat suitability of each site based on gravel mobility and sand transport rates.**
   a. DWR developed a 2D hydraulic model of Reach 1A in 2009 (DWR, 2010). The existing mesh for this model will be evaluated for appropriateness and applied where possible to eliminate duplication of previous efforts.
   b. DWR/Tetra Tech will provide updated elevations for creating a mesh with the most recent topography and project horizontal and vertical datum.
   c. DWR/Tetra Tech will use simulations of monitored pulse flow conditions and provide calibration and validation data for the model using water surface elevation and ADCP survey data, respectively. DWR understands that USBR may be preparing similar model simulations for other purposes. If so, their efforts will not be duplicated but instead leveraged to provide additional information not provided by their analyses.
   d. DWR will use the model results to compare the hydraulics experienced at each tracer's initial location with the measured Shields value. This comparison will provide a validation of the force-gauge-measured critical shear stress.
   e. DWR will calibrate gravel transport rate equations using the measured critical shear stress, bed grain size, and others' bedload transport measurements. The most accurate and appropriate sediment transport formula as determined by comparison with the bedload samples at varying discharges will be an end product.
   f. DWR will use the hydraulic model to run flushing flow scenarios to predict the mobile area of spawning areas. The metric will be the shear stress in excess of the measured critical shear stress. Model nodes in exceedance will be used to delineate polygons where gravel will be mobilized.
   g. The sand transport rates will be used with results from the sand accumulation study to quantify the longevity of clean spawning gravels. Transport rates will be applied to measured trap efficiency of cleaned gravel surfaces. Accumulated sand can then be mapped into polygons or gradationally. Spawning areas can then be compared for expected longevity and rehabilitation potential.
   h. DWR will provide SJRRP participants, through a Technical Memorandum (TM) and the Annual Technical Report (ATR), validated predictions of the effects of alternative flow scenarios on spawning gravels.

5. Schedule

The proposed work will be implemented based on the following timeline.

1. Identify priority reach boundaries and target areas from readily available model predictions of suitable flow depth and velocity with collaborators and fish specialists by November 2013.
2. Focus bed mobility field activities around areas most likely to experience bed mobilization at high frequency return intervals by November 2013.
3. ADCP and water surface elevation flow monitoring activities will begin in WY2014 and conclude after a "bankfull" flow event (greater than 1,500cfs).
4. Sand influx and storage surveying will commence in November 2013 through Winter 2014.
5. The 2d hydraulic model will be calibrated and validated using monitored flows in Winter 2015.
6. Preliminary critical shear stresses from force gauge survey results and predicted gravel mobilization areas will be reported by June 2015.

6. Deliverables

Deliverables for this effort will consist of a preliminary TM and final TM as well as ATR updates. The preliminary TM will document methods used and the preliminary, non-validated critical shear stress for each location for use in interim calculations. A final TM will include the appropriate calibrated and validated sediment transport formulae, monitored sand storage and sand supply rates, and spawning gravel depletion rate based on several flow scenarios and grain sizes. GIS shape files will be provided that delineate areas predicted to be maintained via gravel flushing (i.e. entrainment) and at risk of degradation due to sand accumulation (i.e. high supply rate as bedload).

7. Point of Contact/ Agency

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