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Deriving Vegetation Characteristics from LIDAR Data and Two-Dimensional Hydraulic Modeling of the San Joaquin River Floodplain

Final
2015 Monitoring and Analysis Plan

SAN JOAQUIN RIVER
RESTORATION PROGRAM

January 2015

1.0 Deriving Vegetation Characteristics from LIDAR Data and Two-Dimensional Hydraulic Modeling of the San Joaquin River Floodplain

Themes:

- Flow management
- Rearing habitat
- Conveyance
- Long-term monitoring

Related Questions:

- How does variation in vegetation characteristics of the riparian corridor affect hydraulic resistance at moderate to high flows and what influence does the variation have on floodplain inundation, channel conveyance, and water surface elevation?

- Can in-situ vegetation characteristics be reliably derived from Light Detection and Ranging (LIDAR) data to produce spatial mapping for input into the two-dimensional hydraulic model?

- Can in-situ habitat cover characteristics be reliably derived from LIDAR data to produce spatial mapping for input into habitat quality metrics?

- RH-023: What are the effects of channel narrowing and a mature riparian forest on channel stability and flood capacity/safety?

- RH-021: How does roughness provided by riparian vegetation affect flow residence time on the floodplain and temperature in the main channel? How does floodplain roughness affect juvenile usage and carrying capacity?

1.1 Statement of Need

Revegetation of floodplains along the San Joaquin River is being studied as a possible component of San Joaquin River Restoration Program (SJRRP) in order to reduce water temperatures and promote greater production within the system. Promoting vegetation establishment and growth presents a management challenge due to the priority of maintaining ecosystem function while sustaining conveyance for irrigation and flood control. A comprehensive physical understanding of how varying vegetation characteristics influence the hydraulics within the system is necessary in order to guide restoration management decisions. Two-dimensional hydraulic modeling using functional relationships between vegetation characteristics and roughness provides an analytical tool to quantify differential effects of changes in vegetation size, density, and spatial distribution. Additional challenge lies in the exercise of measuring and processing relevant vegetation characteristics over large spatial extent in order to generate the necessary input data to drive the hydraulic model. Technology such as LIDAR offers a promising solution in that it provides continuous spatial elevation data with differentiation between ground level and vegetation canopy height. In cases where LIDAR studies have already been built into the project scope, additional use of the data for documenting vegetation characteristics could significantly increase the value of the LIDAR studies and the vegetation studies to stakeholders while providing rich data sets for modeling purposes.

1.2 Background

The establishment, growth, and decline of riparian vegetation within impacted riverine systems is a growing challenge due to the increasing priority of maintaining ecosystem function while sustaining water supply and providing flood protection. A quantitative two-dimensional model for predicting the interactions between flow and vegetation is currently under development at Reclamation. The model is based upon the SRH-2D package, which contains a two-dimensional flow and mobile bed sediment transport model. The new SRH-2DV package incorporates (A) modules that simulate the establishment, growth, and mortality of various vegetation types and (B) modules that simulate the effect of vegetation on river and floodplain hydraulics through spatially distributed roughness. Initial simulation results from application to a simple case study on the San Joaquin River is complete (Gillihan, 2013; Dombroski, 2014); also discussed is the utility of expanding the predictive capabilities for addressing complex management decisions related to vegetation in the riparian corridor.

Although the functional relationships between vegetation characteristics and roughness built into the model are based on simple algebraic equations that are well documented in the literature (e.g., Jarvela, 2004; Baptist, et al., 2007), application within a spatially distributed dynamic model is challenging due to the corresponding detail of vegetation information required. Preliminary two-dimensional hydraulic modeling of the San Joaquin River with vegetation-based roughness was based on field studies that provided basic statistics on plant size and density (Gillihan, 2013; Dombroski, 2014). Recent studies in other river systems have demonstrated the utility of advanced remote sensing technology for measuring vegetation characteristics (Jalonen et al., 2014; Abu-Aly et al., 2014). SJRRP has contracted a LIDAR survey of the San Joaquin River and bypass channel system to be acquired in late 2014 or 2015. The contracted survey presents an opportunity to leverage existing data sets in a new and innovative direction by exploring the possibilities of extracting vegetation characteristics in order to advance the capabilities of vegetated flow modeling.

Data from the contratcted LIDAR survey of the San Joaquin River and bypass system could be additionally leveraged to investigate quantifiable relationships between vegetation cover and habitat. While not directly related to the hydraulic modeling of vegetated flow conditions described above, proximity to cover is understood to be important in estimating quality and quantity of habitat (San Joaquin River Restoration Program, 2012), and the vegetation characteristics derived from LIDAR data may be useful in evaluationg habitat conditions.

1.3 Anticipated Outcomes

The study will result in several outcomes:

- Thorough quantitative understanding of vegetation characteristics and growth trends in the San Joaquin River and bypass system
- Advancement in the science and engineering utility of remotely sensed data
- Increased predictive capability of the effect vegetation has on conveyance and water delivery as a result of SJRRP management decisions
- [optional] Increased understanding of habitat dependence on vegetative cover

1.4 Methods

Type of Study: modeling

Reaches: Any reach where vegetation, conveyance, and habitat conditions are of great concern

Methodology is comprised of (a) processing LIDAR data and preparation of model input data, (b) hydraulic model refinement and simulation of vegetated flow conditions, and (c) analysis of simulation results.

1) Existing information available includes published information on estimating flow resistance due to vegetation (e.g., Jarvela, 2004; Baptist, et al., 2007)
2) Existing data available includes LIDAR data, anticipated in 2015. Previous LIDAR data may also be available
3) Existing models include two-dimensional hydraulic models of the San Joaquin River, used as a basis for creating vegetated flow models
4) Timing for the study depends on completion of LIDAR survey and availability of data

1.5 Deliverables and Schedule

- Dataset of vegetation characteristics in the San Joaquin River and bypass system derived from contracted LIDAR data set

- Set of written guidelines for the use of LIDAR data in characterizing vegetation size and density

- Vegetated hydraulic models of SJRRP reaches of interest

- Comparison of hydraulic conditions considering vegetation characteristics from prior LIDAR survey (if available) versus contracted LIDAR survey

- Analysis of predicted hydraulic conditions given projected variation in vegetation conditions and levee alternatives

- [optional] Analysis of vegetation-related habitat conditions based on LIDAR data

1.6 Budget

The total cost estimate is $50,000 for 2015.

Table 1-1. Proposed 2015 Budget

Task	Cost
LIDAR data processing	$15,000
Model Refinement	$5,000
Modeling & Analysis	$20,000
Dissemination	$10,000
Total	$50,000

1.7 Point of Contact / Agency Principal Investigator

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1.8 References

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