Changes in Channel Morphology and Floodplain in Clear Creek, California, in Response to Dam Constructions.

Vizcaíno, Pilar
Laboratorio de Hidrobiología, E.T.S.I. Montes, Universidad Politécnica de Madrid

Kondolf, G. Mathias
Department of Landscape Architecture and Environmental Planning and Department of Geography, University of California, Berkeley.

García de Jalón, Diego
Laboratorio de Hidrobiología, E.T.S.I. Montes, Universidad Politécnica de Madrid

Miller, Peter
Department of Landscape Architecture and Environmental Planning, University of California, Berkeley.

ABSTRACT: Here we report a study of the changes in channel morphology and floodplain in response to the construction of Whiskeytown and Saeltzer dams and Saeltzer dam removal in Clear Creek, California. We analyzed hydrologic data from U.S. Geological Survey gauging stations, and land-cover maps developed using GIS techniques, from historical aerial photographs between 1952 and 2003 to measure changes in channel morphology (length and width) as well as surfaces occupied by bars of sedimentation and vegetation. Gauging records show that the dam has reduced frequent floods often viewed as influential in channel form, and that resulted in changes in channel pattern and geometry (decrease in length between 1952 and 2003 from 11783 m to 11247 m. and meander wavelength).Aerial photo analysis demonstrates a net increase in riparian vegetation surface encroaching the channel but simplified in texture. Saeltzer Dam removal in 2001 shows a trend towards riparian vegetation decreasing and bars´surfaces increasing.

1 INTRODUCTION

To date in California, the vast majority of the rivers are damned: 1400 dams over 7.5 m. in height and 60000 m^3 in reservoir capacity impound over 60% of the state´s run-off (California Department of Water Resources, 1984, Mount, 1995) with reductions or eliminations of floodings and seasonal alterations of natural regimes, becoming more stable along the year. Sediment supplies have been greatly reduced too.

Hydrology and sediment supply are both factors responsible for channel morphology and fluvial processes, (Church, 1995). As a consequence of these, reaches downstream of the dams, are usually dominated by exotic species of fishes, much more competitive in stable conditions than autochthonous ones. Furthermore, reduction or elimination of floodings have caused monotone straightened streams with uniform channel profiles and reduction of channel migration, disconnecting channel and floodplain and causing ecosystem losses due to the impoverishment in species of fauna and flora.

This paper reports the effect of the regulation of the rivers in reaches downstream of dams using remote sensing and GIS techniques that allow the analysis of the geomorphological dynamics of these fluvial environments in different spatial and temporal scales.

In this study, we analyzed changes in channel morphology and floodplain in Clear Creek, California, in response to dam constructions, by comparing pre-dam and post-dam conditions. Whiskeytown dam was built between 1960 and 1963 as part of the Trinity River Division of the Central Valley Project. It was designed and constructed primarily to provide water for hydroelectric generation and for agricultural uses in service areas in the Central Valley. This dam trapped coarse sediments, but more importantly, greatly reduced the volume and magnitude of historical flows.(Fig.1).

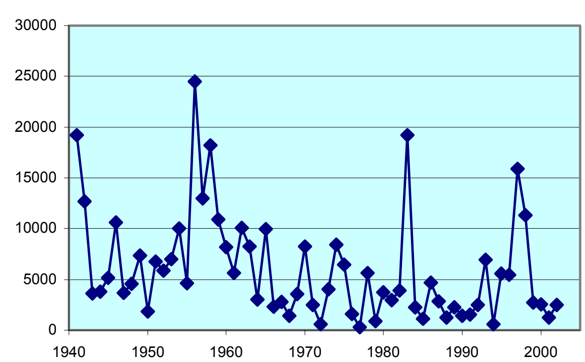

Figure 1: Annual peak streamflow value in cfs before and after dams construction.

Gauging records show that the dam has reduced frequent floods often viewed as influential in channel form, such as the Q2 (reduced from 204 cms to

108 cms). (Hydrologic data from U.S. Geological Survey gauging stations).

Saeltzer Dam was located in lower Clear Creek approximately six miles upstream from the confluence with the Sacramento River. Completed in 1912 to divert water for agriculture and cattle ranching this dam posed a barrier to fish migration, as well as a trap for coarse sediments. In 1990's under pressure from state and federal agencies, plans for alternative water supplies occurred. The definitive dam removal occurred on 2000.

Additionally to these alterations in water and sediment supplies, part of the reach was dredged for gold during the second discovery of gold in California occurred along Clear Creek in 1848, and the tailings deposited onto the floodplain confined the channel (NSR/McBain and Trush, 1999).

1.1 *Study site*

Clear Creek is a 56 Km. long tributary of the Sacramento River originating in the Trinity mountains between the Trinity River and the Sacramento River basins. Is the first major tributary of the Sacramento River downstream Whiskeytown Dam, draining 720 Km^2 . Clear Creek basin has a mediterranean climate with virtually all precipitation, and likewise floods concentrated in winter, although due to the reservoir regulation, flow regimes have been altered.

The project reach is in Shasta County and flows from just below the place where Saeltzer Dam was located, to the mouth of the river into the Sacramento River, in Redding. The reach is about 11 Km. long. (Fig. 2)

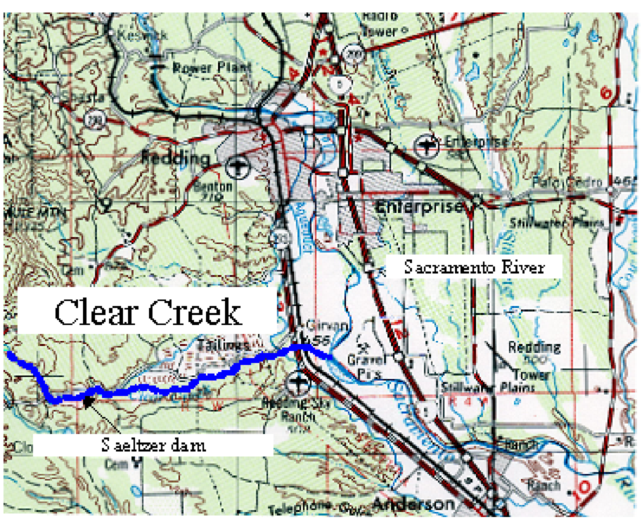

Figure 2: General location of Clear Creek

2 MATERIALS AND METHODS

2.1 *Reach hydraulics*

We studied aerial photographs from different years (1952, 1965, 1977 1988, 1997 and 2003) before and after Whiskeytown dam construction and Saeltzer dam removal. Photos were georeferenced and analyzed with ArcGis. In these pictures we evaluated:

- Changes in channel pattern and geometry measuring changes in length and meander wavelengths. We digitized channel from different years between Saeltzer dam and the mouth of the river.

- Changes in the floodplain. We analyzed changes in riparian vegetation and changes in bars´ surfaces digitizing features only in the first part of the reach (Fig. 3).

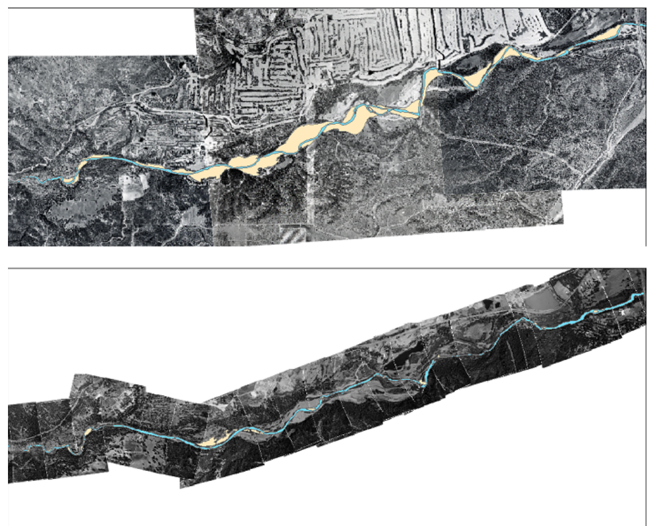

Figure 3: Annual peak streamflow value in cfs before and after dams construction.

We analyzed both changes in total riparian vegetation along a 100 m width buffer, and changes in length of the river bank covered with riparian vegetation, to define correlation between high flows and connection between riparian vegetation and the channel.

Because of the occupation of the floodplain with houses in the reach near Reddding, alterations in riparian vegetation and bars´ surface in this reach couldn´t be explained only as a consequence of the constuction of the dams.

3 RESULTS

3.1 *Changes in channel pattern and geometry*

Values in length between 1952 and 2003 decreased from 11783 m to 11247 m. The highest decreasing in length was observed between 1965 and 1977 corresponding to the years with lowest high flows.

Pre-dam meander wavelengths are longer than post-dam ones.

3.2 *Changes in the floodplain*

3.2.1 Changes in riparian vegetation

As a result of the reduction of annual flows and specially peak flows, riparian vegetation had established along the new low-flow channel and elsewhere in the formerly open active channel (Kondolf, 1998). Analyzing aerial photographs of the reach we found that riparian vegetation increase about 30%, encroaching the channel, but simplified in texture (NSR/McBain and Trush, 1999). This increase is more significant after some years of drought, and after a flood (1997) the channel opens again, reflecting extensive scour and removal of vegetation (Table 1).

Table 1. Changes in total riparian vegetation along a 100 m width buffer.

.

Year	Area of vegetation (m^2)
1952	261143
1965	275973
1977	258347
1988	302356
1997	301645
2003	334586

3.2.1 Changes in bars' surfaces.

We have observed that there has been a great decrease (around 90%) in bar´s surface since Whiskeytown dam was built. Since we don´t have aereal photographs previous to Saeltzer dam construction, we can´t cuantify how much of this decrease is due to the trap of sediments in the dam, but it´s clear that there is a great correlation between changes in flows (specially peak flows) after Whiskeytown dam construction and the stablishment of riparian vegetation over formerly unvegetated bars (Table 2).

Table 2. Changes in bars' surfaces.

Year	Surface (m2)
1952	588702
1965	388870
1977	80738
1988	277367
1997	155664
2003	56281

Peter Miller et al (2004), estimated a volume of eroded material washed downstream of 17006 m^3. after Saeltzer dam removal. In fact, we have observed an increase in bars´ surface inmediately downstream Saeltzer dam in 2003 (after dam removal and after high flows in December 2002).

4 CONCLUSIONS

Construction of Whiskeytown and Saeltzer dams caused changes in flow regime, especially in high flows, and immobilization of sediments. Changes in these characteristics have determined changes in channel morphology measured as channel rectification.

There is a clear correlation between decreasing peak flows and encroachment of riparian vegetation and reduction of area of sediment bars. Further long-term observation and field surveys will clarify changes in vegetation structure.

All these changes, may have resulted in a reduction of fish habitat and changes in fish species appearing new species of alochthonous fishes better adapted to the new conditions than alochthonous ones. Invertebrate production will be affected too. (Ward, 1979).

5 REFERENCES

California Department of Water Resources (1.984): *Dams within jurisdiction of the State of California, Bulletin 17-84,* California Department of water Resources, Sacramento.

Church, M, (1995): Regime Geomorphic Response to River Flow Regulation: Case-Studies and Time-Scales. *Regulated Rivers-Research & Management 11 (1): 3-22.*

Kondolf, G. M., (1998): Lessons learned from river restoration projects in California. *Aquatic conservation: marine and freshwater ecosystems 8: 39-52*.

McBain, and Trush, (1999): Lower Clear Creek floodway rehabilitation project: channel reconstruction, riparian vegetation, and wetland creation design document. Prepared by McBain and Trush, Graham Matthews, North State Resources. Arcata, CA .

Mount, J. F.(1995).California Rivers and Streams*. University of California Press*, Berkeley.

Miller, P., Vizcaíno, P., (2004): Channel response to Dam Removal, Clear Creek, California. *Water Resources Center Archives. Restoration of Rivers and Streams. 21pp.* University of California, Multi-Campus Research Unit.

USGS on-line Surface Water information pages.

Ward. J., V., Stanford, J., A., (1979): The ecology of regulated Streams. *New York Plenum Press*.