Glen Canyon Sloughs Conceptual Design

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Extended Abstract

The U.S. Bureau of Reclamation (Reclamation) completed construction of Glen Canyon Dam in 1963, which began the filling of Lake Powell, which filled for the first time in 1980. The dam and its operations have since significantly changed the flow, sediment, and temperature regimes on the Colorado River, and consequently the geomorphology and ecology of the river corridor downstream from the dam (U.S. Department of Interior, 1995). Changes in the timing of flow and reductions in sediment delivery have caused the channel to incise, narrow, and armor; the once sand bed channel is now primarily gravel and immobile under most flow releases (Pemberton, 1976; Grams et al., 2007).

Given the elevation of the dam's penstocks, water released from the dam is clear and cold, with an average temperature of 8 degrees Celsius (Webb et al., 1999). However, a mega-drought has been gripping the western part of the United States for the past two decades, which has dropped the reservoir level significantly and water temperatures in the mainstem Colorado River are increasing. Exacerbating these changing environmental conditions are an upper and lower backwater slough located on the Colorado River 3.5 miles downstream of Glen Canyon Dam (roughly 12 miles upstream of Lee's Ferry, RM -12) that have created favorable habitat for invasive fish species through increased water temperatures; the sloughs have shallow, nearly stagnant water, making them susceptible to solar heating (Figure 1). Temperature data show upwards of a 17-degree (Celsius) difference between the sloughs and mainstem Colorado River during summer months. Annual efforts are now needed to remove non-native fish from these sloughs. In a 2016 Long-Term Experimental and Management Plan Biological Opinion, Reclamation was directed to alter the sloughs to make them unsuitable or inaccessible to warmwater non-native species. The goal of the project is to cool water temperatures to the extent possible so that non-native green sunfish, smallmouth bass, and other invasive warmwater fish do not find favorable conditions that allow them to propagate in these off-channel areas and impact native fish including the endangered humpback chub.

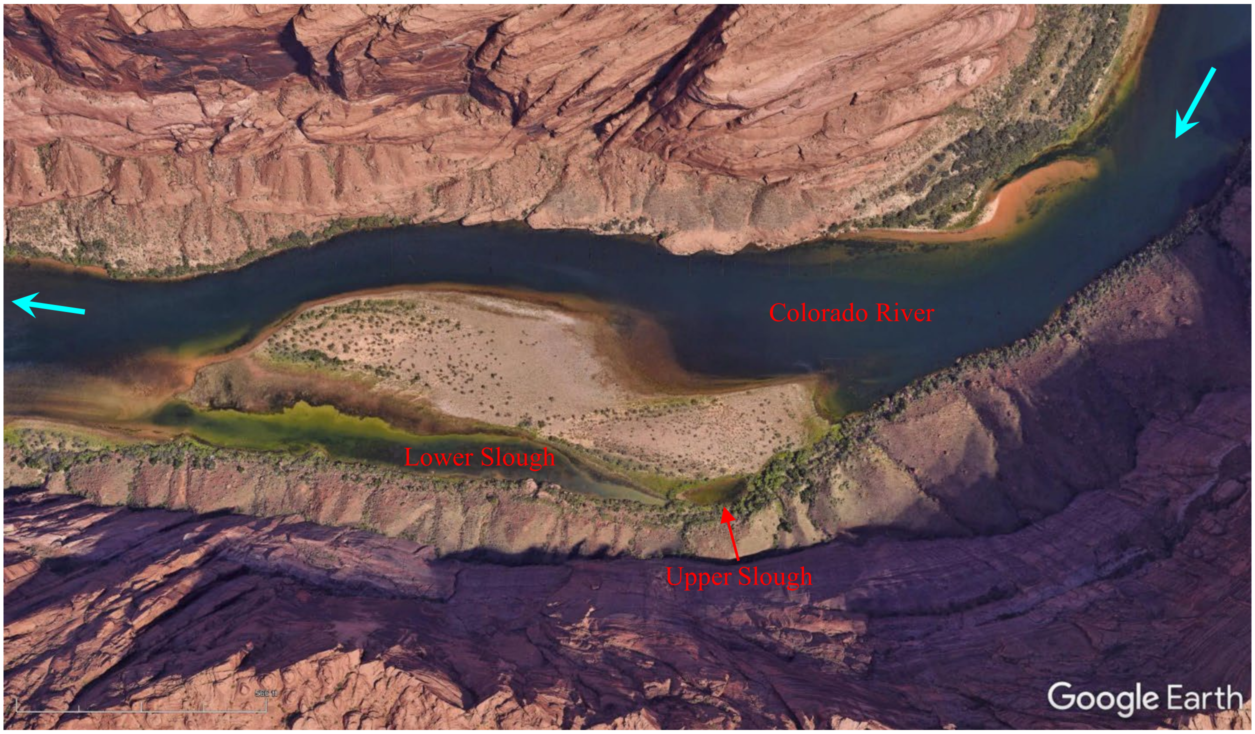

Figure 1. Backwater sloughs on the Colorado River below Glen Canyon Dam; flow is from right to left.

A two-dimensional depth-averaged hydraulic model (SRH-2D) was utilized to evaluate the existing and alternative conditions. Under existing conditions, model results indicate that the gravel bar are sloughs begin to become inundated when Colorado River flows exceed 20,000 cfs, which corresponds to a 10% annual exceedance peak flow.

Several conceptual alternatives were developed in 2018 with the objective of eliminating the non-native fish habitat created by the sloughs. To meet this objective, alternatives included ways to drain the upper slough, fill-in the upper and/or lower slough(s), or meet a water temperature reduction goal. A total of eight conceptual alternatives were developed. Each alternative was evaluated under various levels of analysis and compared amongst each other using criteria such as cut/fill volumes, level of operations and maintenance (O&M), and area of disturbance (Table 1). Required maintenance was foreseen to include such activities as sediment removal to maintain excavations as designed and pipe/culvert connections, promotion of vegetation establishment, and equipment maintenance. All alternatives were assumed constructable; however, the level of constructability is another important consideration given the remoteness of the project site and it being within the Glen Canyon National Recreation Area. General recommendations were made for each alternative, but a preferred alternative was not selected. The greatest foreseen risk of all proposed alternatives is a no-change net effect, where favorable spawning conditions for non-native fish species persist.

Table 1. Summary of conceptual alternative comparisons.

Alter-native	**Description**	**Habitat Control Goal Met?**	**Cut/Fill Volume (yd^3)**	**O&M Level**	**Area of Disturbance**
1.1	Deep channel excavation from the main channel to the Upper Slough, without filling Upper Slough	Yes, for both Sloughs	1,400	Medium	12,000 ft^2 channel cut area
1.2	Shallow channel excavation from the main stem to the Upper Slough, with filling the Upper Slough	Yes, for both Sloughs, but not for the entire summer period	600	Medium	12,000 ft^2 channel cut area + portion of Upper Slough filled in
2	Install pipe or culvert to connect flow from river to Upper Slough	Yes, but with many limitations	-	High	Minimal- pipe trench
3	Continually pump cold river water into Upper Slough	Yes, but with many limitations	-	High	None- removable pipe on surface
4	Periodically pump warm water out of Upper Slough	Yes, but removes all water from Upper Slough for short time periods	-	High	None
5	Install permanent fish barrier between Upper and Lower Slough	No and there are many limitations	100	High	1,300 ft^2
6.1	Excavate channel between Upper and Lower Sloughs	Maybe for the Upper Slough only. Non-native fish spawning could still occur	150	Medium	3,400 ft^2
6.2	Excavate channel between Upper and Lower Slough with water control weir	Yes, allows for fish removal and water control in Upper Slough only	<50	Medium	3,400 ft^2

Alter-native	Description	Habitat Control Goal Met?	Cut/Fill Volume (yd^3)	O&M Level	Area of Disturbance
7	Fill-in Upper Slough	Yes, but for Upper Slough Only. Non-native fish spawning could still occur	600	Low	12,800 ft^2
8	Excavate small channel between Upper and Lower Slough, deep channel excavation between main channel and Upper Slough, and partial filling of Lower Slough	Yes, for both Sloughs	TBD	Medium	TBD

The last alternative (#8) has been more recently developed (2022) than the others under a request to re-visit the previously developed alternatives given the rising water temperatures coming out of the dam and includes a combination of prior alternatives. This alternative considers a 3-phased minimalist construction approach with the idea of evaluating the effectiveness of each phase before implementing the next one. Phase 1 proposes to lower the outlet elevation of the upper slough by hand excavating a small narrow channel just big enough to hydraulically connect the two sloughs allowing the upper slough to drain into the lower slough. Once the new channel has been excavated, native vegetation should be planted to cover the bare moist substrate of the upper slough and along the new channel banks and bottom, converting much of the upper slough into floodplain habitat. The deepest portion of the upper slough would likely still be a wet pool that could warm significantly during the summer months providing habitat for non-native invasives. Therefore, phase 2 would involve excavating a new side channel that would connect a very small portion of the Colorado River streamflow through the upper slough and subsequently through the lower slough. Finally, phase 3 would involve narrowing (through filling) the width of the lower slough to an average of 50 feet; the present width of the lower slough is ranges from 100 to 150 feet. The narrower width would increase flow velocities and allow water temperatures to match more closely those of the Colorado River. The implementation details of this last alternative are currently being developed and numerically modeled.

References

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