GCDAMP Knowledge Assessment: Drivers & Constraints

Resource Topic:	Recreational experience
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Resource Characteristic	Driver or Constraint	Strength	Direction	Confidence	Rationale: Strength & Direction	Rationale: Confidence	Recommendations
Glen Canyon walk-in angling access and safety	Flow fluctuation	Strong	Negative Effect	High	Walk-in angling access and safety are functions of Colorado River flow at Glen Canyon Dam, including maximum flow magnitude and duration, minimum flow magnitude and duration, ramp up and ramp down rates and durations, and daily fluctuation, which in turn are functions of both adaptive management RODs and basin supply management (e.g., equalization flows as functions of Colorado River basin hydrology and storage distribution). Flows different from 10 kcfs and/or greater ramp up or down rates along with daily fluctuation decrease angler access and safety .	Surveys of anglers at Lees Ferry (Bishop et al. 1987 and Duffield et al. 2016) indicate preferences for average daily mean flow of 10 kcfs and no daily fluctuations.	Minimize daily mean flows different than 10 kcfs and flow ranges greater than 5 kcfs during operational flows while meeting downstream resource objectives
Glen Canyon walk-in angling access and safety	Flow magnitude	Strong	Negative Effect	High	Walk-in angling access and safety are functions of Colorado River flow at Glen Canyon Dam, including maximum flow magnitude and duration, minimum flow magnitude and duration, ramp up and ramp down rates and durations, and daily fluctuation, which in turn are functions of both adaptive management RODs and basin supply management (e.g., equalization flows as functions of Colorado River basin hydrology and storage distribution). Flows different from 10 kcfs and/or greater ramp up or down rates along with daily fluctuation decrease angler access and safety .	Surveys of anglers at Lees Ferry (Bishop et al. 1987 and Duffield et al. 2016) indicate preferences for average daily mean flow of 10 kcfs and no daily fluctuations.	Minimize daily mean flows different than 10 kcfs and flow ranges greater than 5 kcfs during operational flows while meeting downstream resource objectives
Glen Canyon walk-in angling trout condition	Rainbow trout condition	Moderate	Positive Effect	Medium	Rainbow trout condition is a function of foodbase.	Dodrill et al. 2016, identifies a rainbow trout growth potential as a function of foodbase	Design operational flows to minimize impacts to and manage for foodbase while addressing downstream resource objectives.
Glen Canyon walk-in angling trout abundance	Rainbow trout abundance	Moderate	Positive Effect	Medium	Rainbow trout abundance is driven in part by recruitment, which in turn is a function of Colorado River flow at Glen Canyon Dam, including maximum flow magnitude and duration, minimum flow magnitude and duration, ramp up and ramp down rates and durations, and daily fluctuation, which in turn are functions of both adaptive management RODs and basin supply management (e.g., equalization flows as functions of Colorado River basin hydrology and storage distribution).	Korman et al. 2012, identifies rainbow trout recruitment as a function of Colorado River flow.	Design operational flows to minimize impacts to and manage for rainbow trout recruitment while addressing downstream resource objectives.

Glen Canyon watercraft angling access and safety	Flow fluctuation	Strong	Negative Effect	High	Watercraft angling access and safety are functions of Colorado River flow at Glen Canyon Dam, including maximum flow magnitude and duration, minimum flow magnitude and duration, ramp up and ramp down rates and durations, and daily fluctuation, which in turn are functions of both adaptive management RODs and basin supply management (e.g., equalization flows as functions of Colorado River basin hydrology and storage distribution). Flows different from 10 cfs and/or greater ramp up or down rates along with daily fluctuation decrease angler access and safety .	Surveys of anglers at Lees Ferry (Bishop et al. 1987 and Duffield et al. 2016) indicate preferences for average daily mean flow of 10 kcfs and no daily fluctuations.	Minimize daily mean flows different than 10 kcfs and flow ranges greater than 5 kcfs during operational flows while meeting downstream resource objectives
Glen Canyon watercraft angling access and safety	Flow magnitude	Strong	Negative Effect	High	Watercraft angling access and safety are functions of Colorado River flow at Glen Canyon Dam, including maximum flow magnitude and duration, minimum flow magnitude and duration, ramp up and ramp down rates and durations, and daily fluctuation, which in turn are functions of both adaptive management RODs and basin supply management (e.g., equalization flows as functions of Colorado River basin hydrology and storage distribution). Flows different from 10 cfs and/or greater ramp up or down rates along with daily fluctuation decrease angler access and safety .	Surveys of anglers at Lees Ferry (Bishop et al. 1987 and Duffield et al. 2016) indicate preferences for average daily mean flow of 10 kcfs and no daily fluctuations.	Minimize daily mean flows different than 10 kcfs and flow ranges greater than 5 kcfs during operational flows while meeting downstream resource objectives
Glen Canyon watercraft angling trout condition	Rainbow trout condition	Moderate	Positive Effect	Medium	Rainbow tout condition is a function of foodbase.	Dodrill et al. 2016, identifies a rainbow trout growth potential as a function of foodbase	Design operational flows to minimize impacts to and manage for foodbase while addressing downstream resource objectives.
Glen Canyon watercraft angling trout abundance	Rainbow trout abundance	Moderate	Positive Effect	Medium	Rainbow trout abundance is driven in part by recruitment, which in turn is a function of Colorado River flow at Glen Canyon Dam, including maximum flow magnitude and duration, minimum flow magnitude and duration, ramp up and ramp down rates and durations, and daily fluctuation, which in turn are functions of both adaptive management RODs and basin supply management (e.g., equalization flows as functions of Colorado River basin hydrology and storage distribution).	Korman et al. 2012, identifies rainbow trout recruitment as a function of Colorado River flow.	Design operational flows to minimize impacts to and manage for rainbow trout recruitment while addressing downstream resource objectives.
Flatwater floating in Glen Canyon NRA	Past HFEs	Strong	Negative Effect	High	The occurrence of HFEs has precluded day-trip rafting in Glen Canyon below Glen Canyon Dam to Lees Ferry.	Day-trip rafting is canceled during HFE events	Minimize duration and magnitude of experimental flows that create access issues while still accomplishing downstream resource objectives

Whitewater usable campsite area	Flow magnitude	Strong	Negative Effect	High	The usable campsite area for whitewater recreational users is a function in part of Colorado River flow at Glen Canyon Dam, including maximum flow magnitude and duration, minimum flow magnitude and duration, ramp up and ramp down rates and durations, and daily fluctuation, which in turn are functions of both adaptive management RODs and basin supply management (e.g., equalization flows as functions of Colorado River basin hydrology and storage distribution). Deposition during high flows increases usable campsite size. Erosion during sustained high flows erodes sandbars and results in less exposed sand for usable campsites. Long-duration low flows result in lower rates of bar erosion and more exposed sand for usable campsites.	Consistent with theory. Consistent results from repeated high-flow experiments. Observed during 2011 sustained high flows. Observed during periods of low flows (e.g. fall steady flows).	Short-duration high flows are effective for increasing usable campsite area.
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Whitewater usable campsite area	Riparian vegetation expansion	Strong	Negative Effect	High	Vegetation encroaches on campsite area.	Vegetation encroachment has been observed in many campsite studies.	Vegetation management may be required to change campsite area.
Whitewater river running experience (i.e., rapids)	Flow fluctuation	Strong	Negative Effect	High	Glen Canyon Dam operations control maximum flow magnitude and duration, minimum flow magnitude and duration, ramp up and ramp down rates and durations, and daily fluctuation, which in turn are functions of both adaptive management RODs and basin supply management (e.g., equalization flows as functions of Colorado River basin hydrology and storage distribution). Daily fluctuation creates an extra challenge as to what time of day is ideal to run major rapids.	Faster down ramp rates could effect how each rapid is most safely run, based on timing.	Minimize daily fluctuations, especially at lower water releases.

Whitewater river running experience (i.e., rapids)	Flow magnitude	Strong	Positive Effect	High	Glen Canyon Dam operations control maximum flow magnitude and duration, minimum flow magnitude and duration, ramp up and ramp down rates and durations, and daily fluctuation, which in turn are functions of both adaptive management RODs and basin supply management (e.g., equalization flows as functions of Colorado River basin hydrology and storage distribution). Higher water releases, to a point (e.g. 22 kcfs) relate to ideal boating conditions for whitewater.	Higher flows improve ability to avoid obstacles.	During equalization years, spread high monthly releases throughout summer months to minimize the amount of sediment eroded out of the Canyon.
Whitewater time on river	Flow fluctuation	Strong	Negative Effect	Medium	Glen Canyon Dam operations control maximum flow magnitude and duration, minimum flow magnitude and duration, ramp up and ramp down rates and durations, and daily fluctuation, which in turn are functions of both adaptive management RODs and basin supply management (e.g., equalization flows as functions of Colorado River basin hydrology and storage distribution). Less time on river leads to more off-river recreational time. Operational flows can have a negative effect on recreational users depending on where they are in the canyon; those corridors where daily fluctuations are at the low make for arduous progress.	Effects more obvious in off-peak months.	Slow down-ramp rates and minimize daily fluctuations.
Whitewater time on river	Flow magnitude	Strong	Positive Effect	High	Glen Canyon Dam operations control maximum flow magnitude and duration, minimum flow magnitude and duration, ramp up and ramp down rates and durations, and daily fluctuation, which in turn are functions of both adaptive management RODs and basin supply management (e.g., equalization flows as functions of Colorado River basin hydrology and storage distribution). Less time on river leads to more off-river recreational time. Higher releases result in faster current.	Under this resource characteristic, equalization flows relate to more recreational time off-river.	When possible, consider spreading equalization flows evenly throughout water year to minimize negative impacts of equalization flows on sandbars.
Whitewater boat mooring (i.e., reduced beaching risk)	Flow fluctuation	Strong	Negative Effect	High	Glen Canyon Dam operations control maximum flow magnitude and duration, minimum flow magnitude and duration, ramp up and ramp down rates and durations, and daily fluctuation, which in turn are functions of both adaptive management RODs and basin supply management (e.g., equalization flows as functions of Colorado River basin hydrology and storage distribution). Daily fluctuations of 8 kcfs combined with faster down-ramp rates equate to a higher likelihood of beached boats. Depending on location this can relate to a high-consequence situation.	Certain beaches/ corridors have a higher likelihood of getting beached. Depending on congestion there may be fewer choices.	Minimize daily fluctuations, especially at lower water releases.

Whitewater boat mooring (i.e., reduced beaching risk)	Flow magnitude	Weak	Positive Effect	High	Glen Canyon Dam operations control maximum flow magnitude and duration, minimum flow magnitude and duration, ramp up and ramp down rates and durations, and daily fluctuation, which in turn are functions of both adaptive management RODs and basin supply management (e.g., equalization flows as functions of Colorado River basin hydrology and storage distribution). With lower fluctuations during equalization, chances of beached boats goes down significantly.	Based on flows greater than 23 kcfs	No recommendations
Whitewater river crowding (i.e., rapids, beaches)	Flow fluctuation	Strong	Negative Effect	High	Glen Canyon Dam operations control maximum flow magnitude and duration, minimum flow magnitude and duration, ramp up and ramp down rates and durations, and daily fluctuation, which in turn are functions of both adaptive management RODs and basin supply management (e.g., equalization flows as functions of Colorado River basin hydrology and storage distribution). Lower water flows (weekend water, holiday flows, MPF flows) create crowding at camps above big rapids.	Based on whitewater guide experience.	Weekend water flows, holiday flows, MPF should be equivalent to mean daily flow for a given month.
Whitewater river crowding (i.e., rapids, beaches)	Flow magnitude	Strong	Positive Effect	High	Glen Canyon Dam operations control maximum flow magnitude and duration, minimum flow magnitude and duration, ramp up and ramp down rates and durations, and daily fluctuation, which in turn are functions of both adaptive management RODs and basin supply management (e.g., equalization flows as functions of Colorado River basin hydrology and storage distribution). At equalization tier, river miles are easy to make, rapids are generally easier to run and crowding is reduced.	Based on flows greater than 23 kcfs	No recommendations
Whitewater navigational risk	Flow fluctuation	Strong	Positive Effect	High	Glen Canyon Dam operations control maximum flow magnitude and duration, minimum flow magnitude and duration, ramp up and ramp down rates and durations, and daily fluctuation, which in turn are functions of both adaptive management RODs and basin supply management (e.g., equalization flows as functions of Colorado River basin hydrology and storage distribution). Flow fluctuations increase navigational risk.	Based on monthly discharge table modeled in LTEMP EIS	Consider 8 kcfs as a minimum flow.

Whitewater navigational risk	Flow magnitude	Strong	Positive Effect	High	Glen Canyon Dam operations control maximum flow magnitude and duration, minimum flow magnitude and duration, ramp up and ramp down rates and durations, and daily fluctuation, which in turn are functions of both adaptive management RODs and basin supply management (e.g., equalization flows as functions of Colorado River basin hydrology and storage distribution). Higher flows relates to less rocks in the channel to avoid.	Based on flows greater than 23 kcfs	When possible, consider spreading equalization flows evenly throughout water year to minimize negative impacts of equalization flows on sandbars.
Whitewater navigational risk Diamond down	Flow fluctuation	Strong	Positive Effect	High	Glen Canyon Dam operations control maximum flow magnitude and duration, minimum flow magnitude and duration, ramp up and ramp down rates and durations, and daily fluctuation, which in turn are functions of both adaptive management RODs and basin supply management (e.g., equalization flows as functions of Colorado River basin hydrology and storage distribution). Flow fluctuations increase navigational risk.	Based on monthly discharge table modeled in LTEMP EIS	8kcfs should be minimum flow.
Whitewater navigational risk Diamond down	Flow magnitude	Strong	Positive Effect	High	Glen Canyon Dam operations control maximum flow magnitude and duration, minimum flow magnitude and duration, ramp up and ramp down rates and durations, and daily fluctuation, which in turn are functions of both adaptive management RODs and basin supply management (e.g., equalization flows as functions of Colorado River basin hydrology and storage distribution). Higher flows relates to less rocks in the channel to avoid.	Based on flows greater than 23 kcfs	When possible, consider spreading equalization flows evenly throughout water year to minimize negative impacts of equalization flows on sandbars.
Backpacking/day-use usable campsite area	Flow fluctuation	Strong	Negative Effect	High	Glen Canyon Dam operations control maximum flow magnitude and duration, minimum flow magnitude and duration, ramp up and ramp down rates and durations, and daily fluctuation, which in turn are functions of both adaptive management RODs and basin supply management (e.g., equalization flows as functions of Colorado River basin hydrology and storage distribution). Deposition during high flows increases usable campsite size. Erosion during sustained high flows erodes sandbars and results in less exposed sand for usable campsites. Long-duration low flows result in lower rates of bar erosion and more exposed sand for usable campsites.	Consistent with theory. Consistent results from repeated high-flow experiments. Observed during 2011 sustained high flows. Observed during periods of low flows (e.g. fall steady flows).	Short-duration high flows are effective for increasing usable campsite area.

Backpacking/day-use usable campsite area	Flow magnitude	Strong	Negative Effect	High	Glen Canyon Dam operations control maximum flow magnitude and duration, minimum flow magnitude and duration, ramp up and ramp down rates and durations, and daily fluctuation, which in turn are functions of both adaptive management RODs and basin supply management (e.g., equalization flows as functions of Colorado River basin hydrology and storage distribution). Deposition during high flows increases usable campsite size. Erosion during sustained high flows erodes sandbars and results in less exposed sand for usable campsites. Long-duration low flows result in lower rates of bar erosion and more exposed sand for usable campsites.	Consistent with theory. Consistent results from repeated high-flow experiments. Observed during 2011 sustained high flows. Observed during periods of low flows (e.g. fall steady flows).	Short-duration high flows are effective for increasing usable campsite area.
Backpacking/day-use shore access	Flow fluctuation	Strong	Negative Effect	Medium	Glen Canyon Dam operations control maximum flow magnitude and duration, minimum flow magnitude and duration, ramp up and ramp down rates and durations, and daily fluctuation, which in turn are functions of both adaptive management RODs and basin supply management (e.g., equalization flows as functions of Colorado River basin hydrology and storage distribution). Deposition during high flows increases usable campsite size. Erosion during sustained high flows erodes sandbars and results in less exposed sand for usable campsites. Flows different from 10 kcfs and/or greater ramp up or down rates along with daily fluctuation decrease angler access and safety .	Higher flow rates and greater fluctuations limit shoreline access (e.g., inundated beaches) and availability (changing water levels)	Minimize daily mean flows different than 10 kcfs and flow ranges greater than 5 kcfs during operational flows while meeting downstream resource objectives
Backpacking/day-use shore access	Flow magnitude	Strong	Negative Effect	Medium	Glen Canyon Dam operations control maximum flow magnitude and duration, minimum flow magnitude and duration, ramp up and ramp down rates and durations, and daily fluctuation, which in turn are functions of both adaptive management RODs and basin supply management (e.g., equalization flows as functions of Colorado River basin hydrology and storage distribution). Deposition during high flows increases usable campsite size. Erosion during sustained high flows erodes sandbars and results in less exposed sand for usable campsites. Flows different from 10 kcfs and/or greater ramp up or down rates along with daily fluctuation decrease angler access and safety .	Higher flow rates and greater fluctuations limit shoreline access (e.g., inundated beaches) and availability (changing water levels)	Minimize daily mean flows different than 10 kcfs and flow ranges greater than 5 kcfs during operational flows to address annual hydrology.

Backpacking/day-use shore availability	Flow fluctuation	Strong	Negative Effect	Medium	Glen Canyon Dam operations control maximum flow magnitude and duration, minimum flow magnitude and duration, ramp up and ramp down rates and durations, and daily fluctuation, which in turn are functions of both adaptive management RODs and basin supply management (e.g., equalization flows as functions of Colorado River basin hydrology and storage distribution). Deposition during high flows increases usable campsite size. Erosion during sustained high flows erodes sandbars and results in less exposed sand for usable campsites. Fluctuations greater than 5 kcfs decrease backpacker and day-use river shoreline availability. Higher flow rates and greater fluctuations limit shoreline access (e.g., inundated beaches) and availability (changing water levels).	Higher flow rates and greater fluctuations limit shoreline access (e.g., inundated beaches) and availability (changing water levels)	Minimize daily fluctuations greater than 5 kcfs during operational flows while meeting downstream resource objectives
Backpacking/day-use shore availability	Flow magnitude	Strong	Negative Effect	Medium	Glen Canyon Dam operations control maximum flow magnitude and duration, minimum flow magnitude and duration, ramp up and ramp down rates and durations, and daily fluctuation, which in turn are functions of both adaptive management RODs and basin supply management (e.g., equalization flows as functions of Colorado River basin hydrology and storage distribution). Deposition during high flows increases usable campsite size. Erosion during sustained high flows erodes sandbars and results in less exposed sand for usable campsites. Fluctuations greater than 5 kcfs decrease backpacker and day-use river shoreline availability. Higher flow rates and greater fluctuations limit shoreline access (e.g., inundated beaches) and availability (changing water levels).	Higher flow rates and greater fluctuations limit shoreline access (e.g., inundated beaches) and availability (changing water levels)	Minimize daily fluctuations greater than 5 kcfs during operational flows while meeting downstream resource objectives
Wilderness experience	Annual whitewater and aircraft launches for resource management, research, and transportation activity	Weak	No Effect	High	Resource and research river trips have a minimal impact, and while aircraft launches have a significant negative impact to wilderness experience, overflights for research (versus recreation) are uncommon.	The impact of helicopters and overflights is impossible to ignore.	Helicopter use should be for emergencies only.
Wilderness experience	Annual whitewater and aircraft launches for recreational visitors	Weak	Negative Effect	High	The number of annual launches do not effect the wilderness experience so long as flows are adequate (see separate driver), but recreational aircraft launches have a significant negative impact to wilderness experience.	Low flows are when the wilderness experience begins to be compromised. The impact of helicopters and overflights is impossible to ignore.	8 kcfs should be minimum flow.

Whitewater usable campsite area	Flow fluctuation	Strong	Positive Effect	High	This entry row was moved from the original Sediment spreadsheet to here because it addresses the topic specifically from the perspective of recreation, but edited for consistency with other driver entries. Deposition during brief high flows increases campsite size, while the effects of sustained flows depend on whether it is a sustained high- or a sustained low-flow event.	Consistent results from repeated high-flow experiments.	Short-duration high flows are effective for increasing campsite area.
Whitewater usable campsite area	Flow magnitude	Strong	Negative Effect	Medium	This entry row was moved from the original Sediment spreadsheet to here because it addresses the topic specifically from the perspective of recreation, but edited for consistency with other driver entries. Erosion during sustained high flows erodes sandbars and results in less exposed sand for campsites, whereas sustained low flows result in lower rates of bar erosion and more exposed sand for campsites.	Consistent with theory. Observed during 2011 sustained high flows.	
Whitewater usable campsite area	Riparian vegetation expansion	Strong	Negative Effect	High	This entry row was moved from the original Sediment spreadsheet to here because it addresses the topic specifically from the perspective of recreation, but edited for consistency with other driver entries. Riparian vegetation expansion encroaches on campsite area. (Conversely, loss of riparian vegetation increases campsite area).	Vegetation encroachment has been observed in many campsite studies.	Vegetation management may be required to change campsite area.