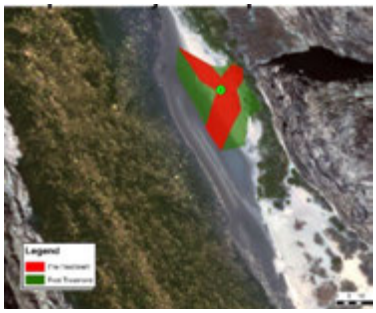
National Park Service
U.S. Department of the Interior
Grand Canyon National Park and
Glen Canyon National Recreation Area

Long Term Experimental and Management Plan

Riparian Vegetation Project Plan

FOR THE IMPLEMENTATION OF THE VEGETATION ENVIRONMENTAL COMMITMENTS FROM THE LTEMP ROD IN GLEN CANYON NATIONAL RECREATION AREA AND GRAND CANYON NATIONAL PARK BELOW GLEN CANYON DAM


Authored by NPS in coordination with
the Grand Canyon Monitoring and Research Center (GCMRC).
Project planned in partnership with the Tribes associated with the Glen Canyon Dam Adaptive Management Program (GCDAMP), and with funding from GCDAMP through the Bureau of Reclamation

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List of Acronyms

GLCA: Glen Canyon National Recreation Area
GCMRC: Grand Canyon Monitoring and Research Center
GRCA: Grand Canyon National Park
LTEMP EIS: Glen Canyon Dam Long Term Experimental and Management Plan Environmental Impact Statement
NPS: National Park Service
TWP: Triennial Work Plan
ACRE3: *Acroptilon repens* (Russian knapweed)
AGUTK: Agave utahensis var. kaibabensis (Kaibab agave)
ALMA12: *Alhagi maurorum* (camelthorn)
COJU2: *Cortaderia jubata* (purple pampas grass)
CUPA: Cucurbita palmata (coyote gourd)
COSE4: *Cortaderia* selloana (Uruguayan pampas grass)
ELAN: *Elaeagnus angustifolia* (Russian olive)
FRVE2: *Fraxinus velutina* (velvet ash)
LELA2: Lepidium latifolium (perennial pepperweed)
PLSE: *Pluchea sericea* (arrowweed)
POFR2: *Populus fremontii* (Fremont cottonwood)
SAEX: Salix exigua (coyote willow)
SAGO: *Salix gooddingii* (Goodding's willow)
SARA3: *Saccharum ravennae* (Ravenna grass)
SATR12: *Salsola tragus* (Russian thistle)
STPI: *Stanleya pinnata* (desert princesplume)
TARA: *Tamarix ramosissima* (tamarisk)
TRTE: *Tribulus terrestris* (puncturevine)
VAST3: *Vanclevea stylosa* (pillar false gumweed)

Background

The National Park Service (NPS) proposed a 20 year experimental riparian restoration project as part of the Glen Canyon Dam Long Term Experimental and Management Plan Environmental Impact Statement (LTEMP EIS – U.S. Department of Interior, 2016a). The project is designated in the environmental commitments in the LTEMP Record of Decision (ROD – U.S. Department of Interior, 2016b) as specific mitigation of the impacts of dam operation to the condition of the vegetation communities within the Colorado River Ecosystem. This is in keeping with the environmental commitments typical in a NEPA process and with the 1992 Grand Canyon Protection Act, which call for protecting, mitigating the adverse impacts to, and improving the resources downstream of the Glen Canyon Dam. The project was included as a specific priority of the Glen Canyon Dam Adaptive Management Program (GCDAMP) in the August 2019 Memorandum from the Secretary's Office. The project is intended to be planned and performed in collaboration with the Tribes associated with the GCDAMP and with scientific guidance from the Grand Canyon Monitoring and Research Center (GCMRC). GCMRC can help provide monitoring and research to ensure the project is being implemented most efficiently to achieve the goals specified in the ROD and to answer research questions particularly regarding the appropriate use of native plants for restoration and the protection of cultural resource sites through vegetation management in strategic locations.

The intention of this plan is to provide the rationale and detailed planning for this project. It should be noted that this plan will need to be updated with each triennial workplan, and that any details or lists of project sites may change on an annual basis. In short, this is intended to be an evolving document, not a static plan.

Rationale - Resource issues to be addressed, or not addressed, by this project

This is a brief summary of the issues which the LTEMP EIS (U.S. Department of Interior, 2016a) identified in relation to this project. This section quotes heavily from sections 3.6 and 4.6 of the EIS but is not intended to be comprehensive.

The influence of dam operations on vegetation

Vegetation along the river corridor is affected by the peak magnitudes, daily fluctuations, and seasonal pattern of river flows. Vegetation studies conducted since 1995 indicate that riparian vegetation composition, structure, distribution, and function are closely tied to ongoing dam operations. The general response of riparian vegetation to the operation of Glen Canyon Dam has been well studied (Kearsley and Ayers, 1999; Ralston, 2005, 2010, 2011; Ralston and others, 2014; Sankey and others, 2015; Stevens and Ayers, 1995; Stevens and others, 1995). Most evidence indicates that riparian vegetation composition, structure, distribution, and function are closely tied to ongoing dam operations (Butterfield and others, 2018; Sankey and others, 2015; U.S. Department of Interior, 2016a). There are four specific vegetation issues influenced by dam operations that emerged in the LTEMP EIS that this project specifically seeks to address:

Encroachment of Vegetation on Sandbars

An ongoing trend with operations since the completion of the dam has been the encroachment of New High Water Zone vegetation onto sandy beaches (Hadley and others, 2018a; Kearsley and others, 1994; Webb and others, 2002). Unvegetated or sparsely vegetated sandbars form a fundamental element of the river landscape and are important for riparian habitat for fish and wildlife, cultural resources, and recreation (Bureau of Reclamation, 1995; Wright and others, 2008). Low-elevation sandbars create zones of low velocity aquatic habitat (i.e., backwaters) that may be utilized by juvenile native fish. These low elevation sandbars are also a source of sand for wind transport that may help protect archaeological resources. In addition, beaches provide recreational value for visitors (e.g., camping areas for river and backcountry users). For recreational use (e.g., camping and boating), visitors generally prefer separation bars over reattachment bars because they are composed of finer grained sand, experience less frequent inundation by rising river levels, and have lower velocity conditions for mooring boats (Bureau of Reclamation, 1995). For these reasons this project was designed to mitigate the effects of dam operations on vegetation encroachment of sandbars. The goal is to clear sandbars periodically of vegetation in specific locations. One species that is a particular problem with encroachment is arrowweed (*Pluchea sericea*). Arrowweed is a native species, but it has characteristics of a primary colonizer and quickly occupies open sandbar areas. The LTEMP EIS concluded that arrowweed encroachment is influenced by dam operations, so this project includes this species for control and removal where this species is encroaching on campsites (U.S. Department of Interior, 2016a).

Decrease in native plant species

The LTEMP EIS concluded that dam operations may contribute to the loss of native species and this project is designed to mitigate that loss with targeted revegetation efforts in specific areas. The population of Goodding's willow (*Salix gooddingii*), which is important for its wildlife habitat value as shade for recreation along the river, appears to have been affected by the reduction in flood flows below Glen Canyon Dam on upper riparian terraces, has been in decline, and either no longer occurs at or does not reproduce at two-thirds of the sites where it previously existed (Grand Canyon Wildlands Council, 2011; Mortenson and others, 2008). Along with the coarsening of substrates, the lack of springtime recruitment floods threatens remaining stands; however, high flows during the mid-1980s resulted in some establishment of Goodding's willow in the Grand Canyon (Mortenson and others, 2012; Ralston and others, 2014). Restoration of Goodding's willow and several other native species has been a focus of NPS revegetation efforts (U.S. Department of Interior, 2016a).

Increases in invasive plant species

Dam operations influence invasive plant species, and analysis in the LTEMP EIS showed that operations have generally led to an increase in invasive plants, so this project is designed to mitigate that impact. A number of nonnative plant species, many of which are invasive species, occur throughout the riparian zone; among the most common species are tamarisk (*Tamarix* spp.), Russian olive (*Elaeagnus angustifolia*), camelthorn (*Alhagi maurorum*), Russian thistle (*Salsola tragus*), ripgut brome (*Bromus diandrus*), red or foxtail brome (*Bromus rubens*), cheatgrass (*Bromus tectorum*), yellow sweetclover (*Melilotus officinalis*), spiny sow thistle (*Sonchus asper*), Ravenna grass (*Saccharum ravennae*), perennial peppergrass (*Lepidium latifolium*), and Bermuda grass (*Cynodon dactylon*) (Reclamation 2011d; NPS 2005a).

Operations since the 1996 ROD (U.S. Department of the Interior, 1996) have facilitated the recruitment, establishment, and expansion of both native and nonnative plant species (e.g., tamarisk) throughout the river corridor (Ralston and others, 2014). Furthermore, a recent analysis of vegetation data collected by NPS staff from 2007 to 2010 demonstrated an overall increase in nonnative plant cover, particularly in the New High Water Zone (U.S. Department of Interior, 2016a; Zachmann and others, 2012).

Erosion of Archaeological Resources

There are a number of ways in which dam operations may affect cultural resources, including the periodicity of inundation and exposure, changing vegetation cover, streambank erosion, slumping, and influencing the availability of sediment. Research conducted since the 1995 EIS on the relationship between sand deposits and wind processes continues to provide data that suggest that windblown sand changes the surface of some sites of archaeological and cultural concern where sand supply and wind are active agents (Draut, 2012; Draut and Rubin, 2008; Sankey and Draut, 2014; U.S. Department of Interior, 2016b).

Narrowing and loss of plants in the Old High Water Zone

This is another major issue of vegetation in the canyon, but this issue is not intended to be addressed by this project. As discussed in the LTEMP EIS section 3.6.1, the construction of the Glen Canyon Dam fundamentally changed the riparian area along the Colorado River through Glen and Grand canyons. A zone of riparian vegetation, referred to as the Old High Water Zone, was well established just above the pre-dam scour zone (at and just above the approximately 100,000-cubic feet per second (cfs) stage elevation; Carothers and Brown, 1991). Following dam construction, annual high flows have been limited to approximately 45,000 cfs or lower, except for four higher flow years (1983–1986) since 1965. The overall trend in the Old High Water Zone has been increased mortality of species such as mesquite (*Prosopis glandulosa* var. t*orreyana*) and net-leaf hackberry (*Celtis reticulata*) (Anderson and Ruffner, 1987; Kearsley, 2006; Webb and others, 2011). This is not a problem which this project is intended to address, as this project is limited to addressing the effects of dam operations, rather than dam existence and is limited to actions in the Colorado River Ecosystem (CRE) (U.S. Department of Interior, 2016a).

LTEMP Analysis Conclusions and Direction for this Project

The LTEMP EIS analyzed extensive literature on the background and dynamics of dam effects on vegetation in Section 3.6 and then analyzed the potential effects of different alternatives using the best available science using a modeling approach in Section 4.6. The approach looked at four metrics and a combined metric. The four metrics were native cover, native diversity, native/non-native ratio, and arrowweed. That analysis found that under all alternatives, the overall combined metric for vegetation condition showed that condition would be expected to degrade to some degree, so this experimental riparian project was conceived to mitigate those effects. The selected alternative was expected to perform better on most metrics than other alternatives, but even this alternative was found to likely result in: 1) a decrease in native vegetative cover (12% overall decrease in native plant community cover), 2) a 16% decrease in wetland community cover; 3) a decrease in the ratio of native to nonnative community types (5% decrease in ratio). All of these dynamics varied with the particular alternative, so they were clearly within the

influence of dam operations rather than problems of just dam existence. However, under all alternatives it was found that the Old High Water Zone would continue narrowing, regardless of alternative, because under normal and experimental dam operations flows would not exceed 45,000 cfs. For this reason, the issue of Old High Water Zone narrowing is not addressed by this project (U.S. Department of Interior, 2016a).

The LTEMP EIS states that activities that are included "are expected to modify the cover and distribution of plant communities along the Colorado River and improve the vegetation conditions. These vegetation treatments include removal of nonnative plants, revegetation with native species, clearing of undesirable plants from campsites, and management of vegetation to assist with cultural site protection. All vegetation treatments would occur only within the Colorado River Ecosystem, which could be influenced by dam operations. Native species, such as Goodding's willow and cottonwood (*Populus* spp.), would be planted to increase and maintain populations of these species. Native plant materials would be developed for replanting through partnerships and use of regional greenhouses; this would include the collection of propagules (seeds, cuttings, poles, or whole plants) from riparian areas in both the river corridor and side canyons. Removal of nonnative plants would include mechanical means (e.g., cutting, digging, pulling), smothering, spot burning, or use of herbicides." (U.S. Department of Interior, 2016a).

LTEMP Resource Goals Relevant to this Project

The LTEMP EIS (U.S. Department of Interior, 2016a) provides these resource goals to guide this project:

Riparian Vegetation. Maintain native vegetation and wildlife habitat, in various stages of maturity, such that they are diverse, healthy, productive, self-sustaining, and ecologically appropriate.

Nonnative Invasive Plant Species. Minimize or reduce the presence and expansion of aquatic nonnative invasive species.

Archaeological and Cultural Resources. Maintain the integrity of potentially affected National Register of Historic Places (NRHP)-eligible or listed historic properties in place, where possible, with preservation methods employed on a site-specific basis.

Natural Processes. Restore, to the extent practicable, ecological patterns and processes within their range of natural variability, including the natural abundance, diversity, and genetic and ecological integrity of the plant and animal species native to those ecosystems.

There are also a number of NPS policies that we use to guide this project that can be found in Attachment A. Each park has other plans related to vegetation management, desired future conditions and non-native plant priorities that inform this project and are referenced below.

Overall LTEMP Vegetation Project Design

The NPS, in partnership with Tribes and GCMRC, has proposed a phased implementation of the project which involves:

i) planning and developing pilot projects and experiments related to each objective through science-based prioritization of management locations and objectives;
ii) implementation of pilot projects and experiments;
iii) monitoring, evaluation, and dissemination of pilot project and experiment outcomes
iv) use of adaptive management principles to subsequently (iteratively) develop, implement, and evaluate site-specific riparian vegetation management projects throughout the program life.

This plan will address Glen Canyon Dam Adaptive Management Program Triennial Budget and Work Plan (FY2021 – FY2023) Elements C.7. - Experimental Vegetation Treatment, and D.1. - Geomorphic effects on dam operations and vegetation management for archeological sites. Specific sites and activities at those sites will be determined annually in coordination with Tribes and GCMRC, and with adaptation based on what was learned from the implementation, monitoring and research in the previous years. Details from Triennial workplans or annual site specifics may be appended to this plan as attachments.

Specific project objectives and priorities are detailed below and tie in with existing NPS plans for riparian vegetation management in the river corridor. All work under this project that is funded out of AMP funds will be restricted to the Colorado River Ecosystem, which is a term defined in the 2016 LTEMP ROD. Funding from the AMP will not be used for project areas outside of the area influenced by current dam operations.

The project locations considered for the LTEMP Vegetation Project are from the dam downstream, as far downstream as the western boundary of Grand Canyon National Park. Coordination and/or consultation would occur between land management agencies, Tribes, GCMRC and Bureau of Reclamation as needed well in advance of on-site implementation. Sites would be selected based on ecological, recreational, and cultural resource conditions, with site specific feasibility selection criteria employed using the best available data. Originally, in 2017, the GCMRC assisted the NPS with a pilot project. Also, the Glen Canyon National Recreation Area (GLCA) Restoration Plan and the Grand Canyon National Park (GRCA) Granite Camp restoration project provided a template for this project and helped inform suitable locations and strategies (Ralston and Sarr, 2017). The project was implemented in phases to establish baseline conditions and standardize methods for implementation and monitoring. Adaptive changes will be made to treatment strategies as we learn more and based on results from formal and informal monitoring. Methods for this project are primarily manual, rather than mechanical, due to the proposed wilderness status and remoteness on much of the land in consideration; mechanical treatment methods (e.g. chainsaw tree felling) are evaluated, when deemed necessary, through the Minimum Requirements Analysis process, but can be used in most portions of the Glen Canyon Reach and along the Colorado River corridor through GRCA. A minimum requirements analysis (MRA) is required by law whenever land managers are considering a use prohibited by

Section 4(c) of the Wilderness Act of 1964. Some agency policies may also require an MRA for other uses or activities in wilderness. Although there are other ways to complete an MRA, the Minimum Requirements Decision Guide (MRDG) is a process that was developed by the Arthur Carhart National Wilderness Training Center to help land managers make informed, defensible decisions that comply with the Wilderness Act. The acreage of these target sites will be somewhat limited because of the site criteria and the methods used. However, the experimental vegetation treatments proposed for these targeted sites are viewed as mitigation of impacts from dam operations under the guidance of the Grand Canyon Protection Act and contribute toward achieving the desired conditions in the National Park units. The five Project Objectives as described in Section 6.4 of the LTEMP ROD (U.S. Department of Interior, 2016b) include:

1. Control non-native plant species affected by dam operations, including tamarisk and other highly invasive species;

1. Tamarisk control areas will be prioritized in areas where removal of live tamarisk is most effective, but may also involve clearing away dead tamarisk that remains after tamarisk leaf beetle (*Diorhabda* spp.) kill in some areas;
2. Other highly invasive riparian species such as camelthorn, Ravenna grass, Russian olive, and perennial pepperweed would also be targeted;

2. Develop native plant materials for replanting through partnerships and the use of regional greenhouses;

1. Prioritize native species for propagation;
2. Determine appropriate source areas based on regional genetics research in cooperation with GCMRC;
3. Develop and enhance partnerships with appropriate nurseries;

3. Replant native plant species at priority sites along the river corridor, including native species of interest to Tribes, as follows:

1. In sites of extensive tamarisk mortality;
2. At edges of campsites for shade or to direct visitor access;
3. Areas where wildlife habitat can be improved for the benefit of native species including potential threatened and endangered species habitat (primarily southwest willow flycatcher [*Empidonax traillii* ssp. *extimus*] and western yellow-billed cuckoo [*Coccyzus americanus*]) in key areas;
4. Sandbar/bank stabilization in key areas, including recreational sites.
5. Priorities for project sites will be established annually with input from Tribes and guidance from GCMRC

4. Remove vegetation encroaching on campsites;

1. Sites that NPS determines are priorities would be considered where established recreational camping areas have been lost to encroachment by both native (e.g. arrowweed) and non-native riparian species (e.g. Russian thistle and puncturevine).

5. Manage vegetation to assist with cultural site protection.

1. Priority sites in GRCA would be chosen where GCMRC research has provided evidence of aeolian processes that could potentially benefit stabilization of cultural sites. Site selection will also include consultation with tribal colleagues to ensure compatibility with site management needs.
2. In GRCA non-native vegetation may be removed in these locations to facilitate future river sediment deposition and wind transport of sand, which would be monitored within an adaptive management framework. There may also be limited removal of native vegetation, primarily restricted to arrowweed with very limited situations including other species (mesquite, seep willow [*Baccharis* spp.]).
3. Native upland xeric vegetation could be planted in locations to increase aeolian sediment deposition, decrease erosion, and/or rehabilitate degraded cultural sites (i.e., Objective 3, above).
4. Work with GCMRC to determine if similar processes may be occurring in GLCA.

Conceptual Framework of the Project

The LTEMP EIS preferred alternative was unable to fully address the overall degradation of the vegetation condition below the dam (see Section 4.6.3 and specifically 4.6.3.4 of the LTEMP EIS), though the preferred alternative performed the best overall for vegetation condition. Since operational flows are limited to below 45,000 cfs, the overall size of the riparian area in GRCA and GLCA has been altered and the vegetation density within the riparian area is expected to continue to increase. The vegetation up to the New High Flow Zone of 45,000 cfs and in the narrow root zone buffer beyond are influenced and affected by dam operations. Non-native vegetation and native clonal species such as arrowweed were shown to be increasing under the 1996 ROD Modified Low Fluctuation Flow (MLFF) dam operations and were predicted to increase under all operational scenarios possible resulting from the LTEMP EIS. This vegetation project was written into the preferred alternative and into the ROD as required mitigation to address the influence of dam operations and to protect and improve the vegetation at targeted sites along the river.

The general response of riparian vegetation to Glen Canyon Dam operations has been well studied, particularly as it relates to woody vegetation expansion (Hadley and others, 2018b; Kasprak and others, 2018; Sankey and others, 2015; Scott and others, 2018) and tamarisk population dynamics (Bedford and others, 2018; Porter and Kearsley, 2001; Ralston, 2010, 2011). The weight of evidence indicates that riparian vegetation composition, structure, distribution, and function are closely tied to ongoing dam operations (Butterfield and others, 2020; Butterfield and others, 2018). For the purposes of this framework, ‘riparian vegetation’ is

defined to include all plants found within the fluctuating, new high water, old high water, and pre-dam flood terrace hydrologic zones of the mainstem Colorado River within GRCA. Operations under the 1996 ROD (i.e. Modified Low Fluctuating Flow) facilitated the recruitment, establishment, and expansion of native and non-native plant species (e.g. *Pluchea sericea*, *Tamarix* spp.) throughout the river corridor (Sankey and others, 2015). Despite this overall expansion of riparian vegetation, Goodding's willow and fluvial marshes are in decline and cottonwoods continue to be rare (Kearsley and Ayers, 1996; Mast and Waring, 1997). Furthermore, a recent analysis of vegetation data collected by GRCA from 2007-2010 demonstrated an overall increase in non-native plant cover, particularly in the new high water zone (i.e. < ~35,000 cfs) (Zachmann and others, 2012). Although the previous Modified Low Fluctuating Flow operations did not exceed 25,000 cfs aside from High Flow Events (i.e. ~ 45,000 cfs), the recruitment and growth of native and non-native plants species above the associated stage elevation are affected by normal operations through its influence on water table levels and other environmental conditions (Ralston and others, 2014).

The project includes targeted non-native vegetation removal and other vegetation management actions at important sites within the CRE to mitigate and manage the predicted increases in non-native plants at specific locations. It will also include native species replanting. Key native species such as Goodding's willow have decreased due to dam operations and other factors such as beaver herbivory (see LTEMP EIS Sections 3.6.2 and 3.7.4; U.S. Department of Interior, 2016a). Experimental restoration of Goodding's willow and other species at a limited number of suitable locations could increase and maintain these species in Glen, Marble, and Grand Canyons. Dam operations have led to encroachment of vegetation into open sand beach areas that are desirable for camping, as well as erosion in some areas requiring shifting of camping areas. Targeted removal of vegetation in these areas may assist with maintaining the carrying capacity of the river corridor for camping. Finally, dam operations have created conditions where vegetation has increased in many areas, hindering wind transport of sediment that has and could continue to protect archeological resources. Targeted experimental removal of vegetation in these areas will mitigate these effects and have benefits for cultural resource protection.

Non-flow vegetation treatment and mitigation downstream of Glen Canyon Dam fulfill mandates of the Grand Canyon Protection Act which specifies protecting, mitigating and improving resource conditions, in this case vegetation, within Grand and Glen canyons. This type of work does not set a precedent for the Bureau of Reclamation or the federal government as a whole below other dams because the requirements of the Grand Canyon Protection Act are unique as they are applied to operations of Glen Canyon Dam alone.

Several Glen Canyon Dam Adaptive Management Working Group (AMWG) stakeholders including Tribes, environmental groups and Colorado River Energy Distributors Association (CREDA) originally proposed a non-flow vegetation treatment project as part of the LTEMP. CREDA proposed vegetation work including the campsite clearing projects, because the work would mitigate, to a degree, the loss of open sand areas and retain camping beaches. Discussions between NPS and Hualapai Tribe during the LTEMP consultation indicated great interest in a shared project along the river corridor to target similar areas of importance to the Hualapai. Discussions with Zuni leaders also indicated great interest in this project and desire to be consulted and potentially to have Zuni community members help on the ground with restoration

work. For these reasons, the ROD specifically included the statement, "*NPS will work with Tribal partners and GCMRC to experimentally implement and evaluate a number of vegetation control and native replanting activities on the riparian vegetation within the Colorado River Ecosystem in GCNP and GCNRA*." NPS has conducted meetings each year with Tribes to discuss project areas, seek input on locations where conflicts or priorities might be present for Tribes and to have discussions with Tribes to find ways to encourage involvement from Tribal members and volunteers. NPS continues to consult with Tribes with specific interests in vegetation work for restoring native plants and for those sites where protection of archeological sites might be targeted.

This vegetation project is experimental and adaptive in nature and it is important that on-the-ground work with monitoring continues with GCMRC to critically assess and improve effectiveness and efficiency.

GCMRC Coordination Specifics (updated for FY21-FY23)

NPS will coordinate closely with GCMRC on this project. GCRMC projects C.4 and D.1 of the Glen Canyon Dam Adaptive Management Program Triennial Work Plan for Fiscal Years 2021 – 2023 (FY21-23 GCDAMP TWP) provide for the GCMRC's coordination with NPS and tribal partners in developing the scientific design, project site selection, implementation and monitoring protocols for the experimental vegetation treatments. During this triennial plan period, NPS and GCRMC will continue to develop and implement experiments that evaluate techniques for campsite clearing (GRCA), native species replanting (GLCA, GRCA), and invasive removal (GLCA, GRCA). Additionally, experiments developed in collaboration with GCMRC examining whether and how vegetation removal from sandbars affects cultural resources and sediment dynamics will continue (see GCMRC TWP D.1). The intent of these evaluations is to identify the most effective and environmentally-sensitive methods to achieve the LTEMP ROD principle elements. This will allow for an adaptive management approach to adopt the more efficient approaches over time.

Coordinated activities would include removal of selected plant species of concern at targeted sites and subreaches (e.g., live and dead tamarisk, arrowweed), replanting of native species at targeted sites, and ongoing monitoring of treatment areas. GCMRC project D.1 also provides a formal experimental design for evaluating if vegetation removal increases the probability of "preservation in place" of archaeological sites near HFE-sediment supplied sand bars, including site selection and pre- and post- treatment data collection. This experiment provides the connection for how other LTEMP experiments such as spring, fall or extended HFEs relate to the vegetation work (as HFEs would be predicted to increase sediment at the strategic sandbar locations identified and then be available to be blown by wind to cover archeological sites). This experiment includes appropriate monitoring and controls to determine how much benefit to the covering of cultural sites actually accrues from such vegetation removals; the monitoring methods for evaluating the effectiveness of the experimental vegetation treatments are described in detail in GCMRC project D.1 and thus readers are referred to that document.

Additional funds are available to provide outreach and coordination with Tribes by the NPS/GLCA for FY2020-21. In addition, GCMRC projects C.1, C.2, C.3 and L contribute to the NPS vegetation work in the following ways. Project C.1 provides riparian vegetation monitoring

data between Glen Canyon Dam and River Mile (RM) 240, which can be used to prioritize treatment areas and identify sources of native species for propagation. Project C.2 proposes to conduct manipulative experiments on hydrological tolerances of riparian species of interest, which can be used to inform species used for planting, locations of plantings in relation to surface flows, and anticipated responses of removed plants. Project C.3 proposes to develop predictive models of vegetation responses to flows using existing data from many sources, including data derived from the LTEMP non-flow vegetation experiments described here. These models can be utilized to develop planting and removal plans to increase treatment success. Project L will provide aerial image base maps for planning and navigating purposes, as well as spatial data sets that will contribute to project evaluation.

NPS Vegetation Planning and Specifics

NPS has undertaken extensive non-native plant control efforts throughout the Colorado River corridor, which contains over 100 non-native plant species. NPS focuses non-native plant management activities on those species that pose a high threat to park resources (i.e., those that are highly invasive and disrupt ecosystem function), and ones with a high potential for successful control. An Integrated Pest Management (IPM) approach is used that includes a combination of cultural, manual, mechanical, and chemical treatments. The program aims to control existing populations, prevent new introductions, promote hands-on stewardship, and educate the public. A comprehensive annual work plan, tied to the GRCA Exotic Plant Management Plan Environmental Assessment (National Park Service, 2009), guides field activities in GRCA. While significant resources have been focused on the control of tamarisk in side canyons, work along the mainstem has primarily focused on other non-native species, and has ranged from removal of isolated individuals (e.g. Ravenna grass, Russian olive) to systematic removal of target species at selected sites (e.g. camelthorn, Russian thistle) using both NPS crews and volunteers (e.g. 'Adopt-A-Camp' Program). In addition to activities covered under the GRCA Exotic Plant Management Plan EA (2009), a number of additional riparian rehabilitation treatments in the river corridor have been tested at Granite Camp and Soap Creek, under the Pilot Project to Rehabilitate Native Riparian Community at Granite Camp, Programmatic Categorical Exclusion for River and River Accessible Site Maintenance (2011-2016) and Programmatic Categorical Exclusion for FY15-FY20 Vegetation Program Programmatic Activities. These include, but are not limited to, the selective control and removal of tamarisk, selective control and removal of native plant species encroaching on campsites (e.g., arrowweed), collection and propagation of native plant materials, installation of monitoring transects, and active planting and seeding of native plant species within both the new and old high water zones.

Within GLCA, an EA exists for the Lees Ferry, Lonely Dell and river corridor areas from approximately RM -1 to RM +2 which covers non-native plant control and restoration efforts. There are also an Integrated Pest Management Plan and a River Restoration Plan for GLCA (Grand Canyon Wildlands Council, 2008; NPS 2019). Prioritized sites are included in park documents for the upstream river corridor covering non-native plant control and restoration, archaeological site protection, wildlife habitat enhancement, infrastructure and recreation sites.

Although NPS has not actively introduced biological control agents into GRCA and GLCA as part of its IPM approach, the tamarisk leaf beetle and splendid tamarisk weevil (*Coniatus* spp.)

have naturally dispersed throughout the river corridor from outside of both parks and are actively defoliating tamarisk. The extent of subsequent mortality and associated impacts on riparian ecosystem patterns and processes remain to be seen but is likely to be significant given those that have occurred in the Upper Colorado River Basin where these agents have been active for a longer period of time (National Park Service, 2012 and references therein). This may include the degradation and loss of riparian habitat (e.g. structure and shade currently provided by tamarisk, fire risk posed by dead/dying tamarisk), which may necessitate replacement with native vegetation (e.g. Fremont cottonwood, Goodding's willow) to maintain or enhance current levels of native biodiversity.

It is anticipated that the full suite of treatments outlined above, as well as other methods, will be required to mitigate the direct and indirect impacts of LTEMP dam operations on the riparian community within the Colorado River corridor in GLCA and GRCA. Thus, work will include ongoing monitoring and removal of isolated non-native plants, systematic removal of non-natives at targeted sites, and full-scale restoration at targeted sites and sub-reaches which may include wholesale removal of tamarisk (both live and dead) and revegetation with natives. Treatments will fall into two broad categories: the control of non-native and encroaching native plant species and revegetation with native plant species. Table 1 provides a summary of priority non-native species for control. Non-flow actions may also serve to facilitate an increase in the abundance and/or distribution of specific native plants that are currently underrepresented in the corridor (e.g., Goodding's willow), may provide replacement habitat in the wake of tamarisk mortality (e.g., tree species), and/or are otherwise desirable to meet management objectives like providing barriers to sensitive sites. Some of these species may only be appropriate to encourage within limited areas that are likely to support self-sustaining populations and otherwise meet specific management objectives. Conversely, there are some native species (e.g., arrowweed) that are currently interfering with meeting management objectives (e.g., open sand beaches) and that thus should be systematically disfavored by non-flow management actions. Specific priority native species to target are yet to be determined; that decision will be made on a site by site basis.

Table 1: Priority non-native species for control within the Colorado River Corridor

Scientific Name	Common Name
Acroptilon repens	Russian knapweed
Alhagi maurorum	camelthorn
Brassica tournefortii	Sahara mustard
Convolvulus arvensis	field bindweed
Cortaderia selloana	Pampas grass
Echinochloa crus-galli	barnyardgrass
Eragrostis curvula	weeping lovegrass
Elaeagnus angustifolia	Russian olive
Lepidium latifolium	perennial pepperweed
Malcolmia africana	African mustard
Phoenix dactylifera	date palm
Saccharum ravennae	Ravenna grass
Salsola tragus	Russian thistle
Schedonorus phoenix	tall fescue
Sisymbrium altissimum	tumble mustard
Sisymbrium irio	London rocket
Sonchus asper	spiny sowthistle
Sonchus oleraceus	common sowthistle
Tamarix aphylla	athel
Tamarix spp.	tamarisk/salt cedar
Tribulus terrestris	puncturevine
Ulmus pumila	Siberian elm
Non-native *Phragmites australis*	Reedgrass – a small amount of this mostly native species at Lees Ferry may be the invasive form

Potential actions are outlined below in Table 2. Details of current non-native plant treatment methods on a species-specific basis can be found in the GRCA Exotic Plant Management EA (2009) and tiered annual work plans as well as Grand Canyon Wildlands Council (2008). New or additional management methods would be subjected to further review and will have to be detailed under subsequent compliance. Revegetation actions will solely be focused on ecologically appropriate species that will (typically) be sourced from an appropriate provenance. Collection provenances will be determined on a species by species basis using results from a population genetic study funded by GRCA and conducted by GCMRC and Northern Arizona University (Palmquist and others, *in prep*; U.S. Department of the Interior, 2017). Regardless of treatment type, the scope of all non-flow actions will encompass multiple components including planning, implementation, maintenance, monitoring, outreach, education, and administration. They may also range from small-scale, *ad hoc,* control efforts to large-scale restoration projects that will necessitate significant resources. While activities falling within the scope of the former are covered under existing compliance documents as referenced above, activities falling within the scope of the latter will require additional compliance that will need to be covered under the LTEMP EIS or separately, as appropriate.

Table 2: Riparian vegetation treatments

Treatment Category	*Treatment Type*	*Methods*
Invasive Plant Management	Cultural	Prevention (e.g., education/outreach), smother (e.g. plastic), mulch, spot burn, plant natives (e.g. to form dense cover, see below)
Invasive Plant Management	Mechanical/ Manual	Prune, cut, pull, winch, dig, hoe (e.g., using hand or power tools); dispose (e.g., scatter, pile, burn, dump in river) (may include removal of live/dying/dead tamarisk)
Invasive Plant Management	Chemical	Herbicide applications (e.g., spot spray, basal bark application, treat cut stumps, hack and squirt methods)*
Invasive Plant Management	Biological	Biological control agents (i.e., already established for tamarisk)
Revegetation	Cultural, Mechanical/ Manual	Propagule collection, storage, propagation, and transportation (incl. seeds, cuttings, poles, whole plants utilizing boats and/or helicopters); planting (e.g., broadcast seed, pole/pot plant); mulching; carbon augmentation/fertilizing; wildlife barriers; watering

*In 2020, Pueblo of Zuni expressed the desire to consult further with the park units on herbicide applications so NPS is following up with them.

Project Treatment Areas

As stated above, specific project treatment areas would be selected on an annual basis through coordination with Tribes and GCMRC. See the section above for how GCMRC assists specifically with projects under the current triennial budget. The NPS establishes Priority Treatment Areas (PTAs) each year in coordination with partners (specifically Tribes and GCMRC, but NPS is trying to increase input from other partners such as river guides) in advance to delineate areas within the river corridor that would be considered for treatment first. The treatment areas are generally small project areas along the river chosen based on consideration of how many of the project goals can be fulfilled at the site, based on the likelihood of success given goals at the specific site. These areas are also chosen based on the logistics of the river missions planned for the given year and taking into account priorities and concerns from Tribes and input from staff and other stakeholders regarding the recreational value of given sites. The scale of these project areas is generally less than 10 acres rather than a larger reach-scale given the limitations of budget and river mission/work crew logistics. Attachment C lists the experimental vegetation treatments applied in GRCA and GLCA between FY2019 and FY2020, and Attachment D lists the experimental vegetation treatments planned for GRCA and GLCA in FY2020.

Many of the originally identified sites were selected based on a GIS analysis in coordination with GCMRC using a number of spatial layers (i.e., criteria) that intersect, such that areas (i.e., sites or reaches) with more coincident layers are given a higher priority, noting that individual criteria are not weighted in this preliminary analysis (see Table 3). Prioritization criteria are detailed in Table 3 and the results of this preliminary spatial analysis are depicted in Figure 1. A number of criteria (denoted with an asterisk in Table 3) depend upon GIS datasets that are currently under development, while many of the other criteria are highly variable over space and time (e.g., tamarisk defoliation/mortality). These datasets will require updating over time, but also ground-truthing or flexibility to alter sites based on field findings prior to actual treatment. As the project has evolved, the extensive site knowledge of staff from NPS and GCMRC has helped refine the GIS data and the prioritization based on the combined quantitative and qualitive data sources in the bulleted criteria listed below.

The general criteria used to select project sites are:

1. Does the site fulfill multiple objectives? This evaluation is done using a simple additive score for each objective, including recreation issues (e.g., campsite encroachment, visitor use), infrastructure, invasive non-native plant species present, cultural resource issues, wildlife species presence and available data (legacy data, primarily from bird surveys), and logistics.
2. Does the site fit with river logistics (is the site accessible, how large is the area from a work-crew perspective, in a broader vs. more narrow reach, etc.)?
3. No conflicts with cultural protection or concerns from Tribes.

Specific additional criteria are listed in Table 3, but below is a bulleted list of what is considered in the site selection specifically by category using a variety of quantitative and qualitative information:

1. Control nonnative plant species affected by dam operations, including tamarisk and other highly invasive species
    1. GLCA is targeting tamarisk, but not in heavily used recreation areas due to conflicts with visitor use, and is looking for sites of a reasonable size to fit budget constraints. GLCA is also targeting dead tamarisk presenting a fire risk.
    2. GRCA targets invasive plant species (Russian olive, ravennagrass, camelthorn, etc., as reflected in Table 1.) that are high priorities in the GRCA Exotic Plant Management Plan (2009). This list is adapted further to target those species and areas that are being affected most by dam operations and/or for protection of resource values (for example habitat for southwestern willow flycatcher, northern leopard frog [*Lithobates pipiens*], etc.) or in combination with native replanting sites.

2. Replant native plant species at priority sites along the river corridor, including native species of interest to Tribes
    1. GLCA targets areas that do not have heavy recreation use, that do have a diverse set of native species already present and can be used for replanting. GLCA incorporates plants of tribal interest as appropriate based on input from the Tribes. An emphasis on testing a variety of native species is being implemented, including Goodding's willow, hoptree, Apache plume and desert olive.
    2. GRCA targets sites where they can build on past native replanting efforts, areas that benefit federally listed species, and areas where tamarisk is declining based on beetle mortality. Accessibility is another criterion particularly important for replanting sites.

3. Remove vegetation encroaching on campsites
    1. GRCA maintains a list of known campsites that identifies those that have encroachment where treatment would result in reclaiming campable area.
    2. NPS staff and GRCMC staff have provided additional updated information.
    3. GRCA is trying to increase input from river guides on additional sites.
    4. GLCA sites typically do not have vegetation encroachment issues.

4. Manage vegetation to assist with cultural site protection
    1. GCMRC recommends sites to NPS based on a review of the known archaeological sites combined with historical information about vegetation encroachment, beach building potential, site specific wind direction information and availability of existing monitoring data (part of the GCMRC triennial project D-1).

Table 3: Criteria for Priority Treatment Areas (how these are used may vary depending on which of the four treatment types are being considered)

Category	Variable	Value	Data Source	Rationale
Ecological	Geomorphic reach	Width (reach by RM)	GLCA and GRCA Park Areas	Support larger and more diverse patches of riparian vegetation and wildlife habitat compared to narrow reaches so treatments can be implemented at an ecologically-significant scale.
Ecological	Tamarisk defoliation	Height (degree by RM)	GLCA, GRCA et. al. Tamarisk Beetle Monitoring; Bedford and others, 2018	Areas requiring proactive replacement of habitat where tamarisk beetle/weevil defoliation and flows will create mortality or fire risk. Mortality may be directly measured in future surveys.
Ecological	Proximity to non-native plant sources	RM -15 to +21;	GCMRC River Miles	Includes approx. range of known/potential upstream/tributary sources (e.g. GLCA, Paria, North Canyon) of highly invasive plant species (e.g. Russian olive, puncturevine) where aggressive control can limit downstream spread.
Ecological	Southwestern Willow Flycatcher habitat	Suitable/potential habitat (sites by RM)	GRCA et al. SWFL Surveys; Hidden Slough Restoration Project	Sites where SWFL have been historically detected or nested and where habitat suitability may be improved through proactive vegetation treatments.
Ecological	Vegetation classification*	Tamarisk spp. Ruderal Scrub Alliance (presence)	GRCA Vegetation Map; Durning and others, 2018	Pending derivation from GRCA vegetation map classification and modeled states; extent is dependent upon which model time-step is chosen (i.e. t_0-t_x, see text). Actual work will be guided by future vegetation survey results.
Ecological	Native species richness*	High (# of spp.)	GRCA CRMP, GCMRC TEM, GLCA data; Palmquist and others, 2018	Areas with higher native flora and fauna richness that are threatened by non-native competition.
Ecological	Sources of native woody species*	Large populations (# of individuals)	GRCA CRMP, GCWC, GCMRC, GLCA, SEINet, Phillips and others, 1987; Palmquist and others, 2018	Areas (incl. mainstem /tributaries) with relatively large/sustainable populations for potential pole cuttings of key native woody spp. used for revegetation (e.g. Goodding's willow, Fremont cottonwood, coyote willow). Treatment sites within reasonable proximity of downstream sources would be prioritized due to local provenance and easier transport/feasibility.

Recreational	Campsite use level	High or Low (depending upon which type of treatment – based on frequency of being occupied)	GLCA data; GRCA CRMP	Use levels at CRMP sites (n = 66) are associated with higher levels of non-native cover and potentially higher levels of disturbance and seed vectors. Treatments would also enhance visitor experience.
Recreational	Vegetation encroachment*	High (% incr. from $t_{0\text{-}x}$)	GRCA CRMP, NAU/GCMRC; Hadley and others, 2018b; Palmquist and others, 2018	Campsites with high levels (esp. arrowweed) limit areas for camping and open sand habitat.
Cultural	Dune stability*	High (vegetative cover on sandbars)	GCMRC/USGS; East and others, 2016; East and others, 2017	Sites where vegetation encroachment is limiting aeolian transport of sediment from sandbars to sensitive archeological sites.
Cultural	Social trails*	High (#)	GRCA CRMP; GLCA cultural studies	Campsites with social trails that lead from NHWZ into OHWZ areas with sensitive archeological sites could be revegetated/obliterated to limit access. Pending further consultation.
Cultural	Tribal significance	High (categorical)	Tribal representatives	It is recognized that specific sites and/or species have tribal significance that may not be adequately represented by other criteria.
Feasibility	Proximity to boat launches	Glen Canyon (RM 0 to -15,) Lee's Ferry (RM 0-11), Diamond Creek (RM 205-231), Pearce Ferry (RM 232-279)	GRCA, GCMRC	Reaches where motorboat up/down runs are safe/feasible (pending river levels/rapid rating) to support more logistically practical and cost-effective projects.
Feasibility	Trail accessibility	Campsites accessible by hiking trails (presence)	GRCA Trails	Campsites accessible by foot provide additional access options and potential reduced costs compared to those only accessible by river.

* Denotes variables that are contingent upon future deliverables and/or warrant further analysis and are therefore not currently included in this preliminary prioritization.

Riparian – Subject to Glen Canyon Dam Influence

Desired Condition

The diversity, quality, abundance and distribution of riparian habitats in the Colorado River corridor is maintained at or above the levels found in Grand Canyon in surveys prior to the passage of the Grand Canyon Protection Act (U.S. Department of the Interior, 1992). Patches of vegetation dominated by

native species occur in stands at a range of elevations below the pre-Glen Canyon Dam high water mark. The high levels of native diversity and productivity of these patches is maintained by access to water and nutrients from the hyporheic zone. Wildlife populations, including mammal, avian, herpetofauna and arthropod, are supported in these riparian habitats and sustained at levels that contribute to a functioning community.

Periodic disturbance in the form of flooding and sediment deposition cause turnover of individuals and patches with a frequency that decreases with elevation above the level of base flow. High flows reach levels similar to pre-dam flows rarely. System-wide productivity and diversity are occasionally reduced due to longer-term disturbance from reduced annual flow volumes or extended droughts, but disturbance from human activities, including trampling of vegetation, broken branches, disturbance of soil crusts, etc., is maintained at or below levels of impairment.

Table 4. All work for GRCA will be consistent with moving toward this desired condition from the GRCA Desired Conditions planning framework.

Indicator	*Reference Condition*	*Target*
Areal extent of vegetation	Tamarisk: 600 acres; Other / native: 1900 acres (Kearsley and others, 2015)	Tamarisk: 300 acres (decreasing); Other / native: 2000 acres (increasing)
Cover of native and non-native species (native vegetation types) (%)	71% native; 29% non-native (Kearsley et al, 2001-2005)	90% native 10% non-native
Richness of native species (%)	70% richness of native species (Kearsley et al, 2001-2005)	At least 85% richness of native species
Populations and areal extent (target only) of key rare plant species (#)	TBD (Phillips and others, 1987; herbarium collection through 2011)	# of populations and areal extent, by key species, are stable or increasing
Neotropical avifauna diversity and abundance	TBD	TBD
Yellow-billed cuckoo	TBD	TBD
Areal extent of southwestern willow flycatcher habitat	TBD	TBD

Figure 1 - Priority Treatment Areas in GRCA.

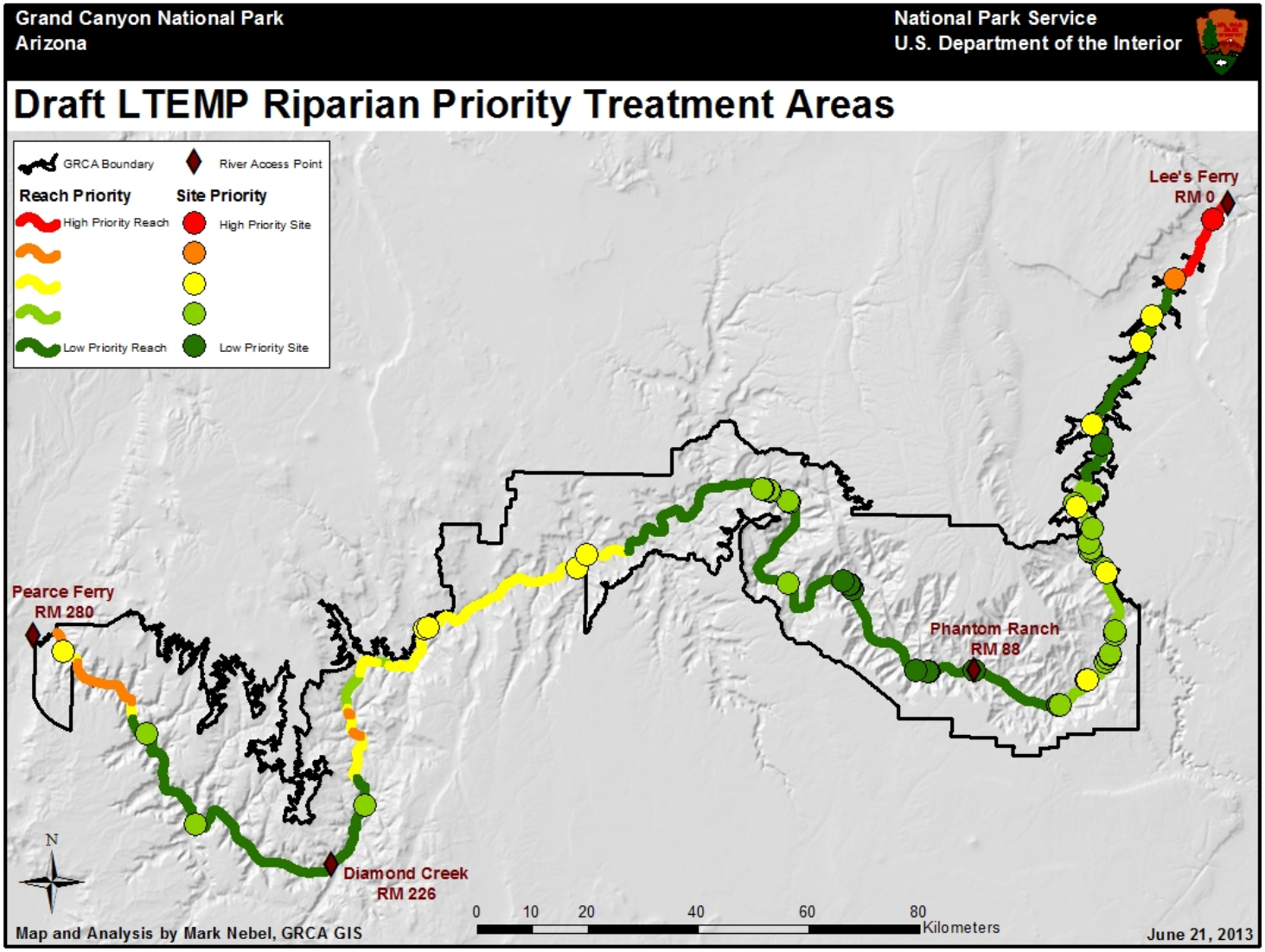


Table 5. **All work for GLCA will be consistent with moving toward desired conditions.**

Indicator	*Reference Condition*	*Target*
Areal extent of vegetation	Unknown but ca. 75% tamarisk, much of which is dead	Tamarisk: 40 acres controlled; increasing dominance of native species
Cover of native and non-native species (native vegetation types) (%)	25% native; 75% non-native	>50% native <50% non-native
Richness of native species (%)	Native species list based on previous survey work	No loss of native riparian species
Populations and areal extent (target only) of key rare plant species (#)	TBD	# of populations and areal extent, by key species, are stable or increasing
Neotropical avifauna diversity and abundance	Avian diversity and abundance based on previous surveys from 1980-2000	Maintain native riparian species in corridor to the extent possible, with a few species declining due to loss of tall tamarisk structure
Yellow-billed cuckoo	Migratory habitat	Maintain high quality migration habitat
Areal extent of southwestern willow flycatcher habitat	Hidden Slough site	Develop 1-2 locations that may be suitable for SWIFL

A detailed vegetation map and an accurate estimate of riparian vegetation from the dam to Lees Ferry was only recently published by GCMRC (Durning and others, 2018) and has not been used yet to guide restoration in GLCA. However, restoration planning includes approximately 12 high priority sites with approximately 200 acres of riparian vegetation. Table 5 indicates desired future conditions for the riparian corridor.

Monitoring

Monitoring for this project has been partially formal and partially informal and is still in development; however, NPS and GCMRC are committed to formalizing monitoring for this project during the 2021-2023 triennial workplan period. This will be either an additional attachment to this plan or a stand-alone monitoring plan. What follows is the beginning of the content that will be formalized in that 'monitoring plan' or attachment.

The second triennial workplan (U.S. Department of the Interior, 2017) provided for the planning for this project and allowed for two pilot seasons of work to be completed. We have learned a great deal from those projects. Collaboration between GCMRC and NPS is now moving into a new phase where more refined hypotheses can be developed for specific aspects of treatment and we can further define what success looks like for our specific goals.

Riparian monitoring includes elements of the CRMP Monitoring Program that is currently under revision (National Park Service, 2006a) and is coordinated with system-wide riparian vegetation monitoring conducted by GCMRC (GCMRC Project C.1; Palmquist and others, 2018) and other projects such as GCMRC Project D.1. Treatment methods used will conform with approved

plans and methods in an environmentally appropriate manner and with consultation from the Tribes. Currently available monitoring approaches from the Escalante River Watershed may be utilized as a basis for the monitoring plan to be developed (Escalante River Watershed Partnership, 2015).

Hypotheses to be tested

Generally, these hypotheses are as follows (to be refined in the monitoring plan/attachment) and designed to achieve the five Project Objectives as described in Section 6.4 of the LTEMP ROD (U.S. Department of Interior, 2016b):

1. Control nonnative plant species affected by dam operations
    1. Can targeted invasive species be effectively reduced or maintained using mechanical, chemical, cultural, and/or biological methods?
    2. Will adopted invasive plant control methods result in a net increase in native plant cover rather than reinvasion by previously controlled invasive or secondary invasive plants?
2. Replant native species to priority sites along the river corridor, including native species of interest to Tribes
    1. Which species and methods most effectively result in the establishment and increase of desirable native species in treatment areas?
    2. Which native plant species perform best in differing environments, i.e., wide vs. narrow reaches, west vs. south orientations, coarse substrates vs. sand vs. silt, elevations above river level, etc.?
    3. Which plant species of tribal interest can most effectively be established and increased in treatment areas?
3. Remove vegetation encroaching on campsites
    1. Can areas of bare sand be effectively maintained with mechanical, chemical, cultural, and/or biological methods?
4. Manage vegetation to assist with cultural site protection
    1. Does removal of riparian vegetation located between HFE-sediment supplied sand bars and archaeologic sites increase the probability of preservation in place?

Current Monitoring Approach

1. Control nonnative plant species affected by dam operations

    1. Evaluating treatment success will occur on an annual basis for two years post-treatment, followed up by longer intervals. Methods will include the use of permanent photo points, species cover estimates, success of native replantings, and surveys to detect the presence of new invasive species. These methods will assist with evaluating treatment success and track plant community changes over time (Hall, 2002). Photos and vegetation data will be collected pre-treatment for use as a baseline comparison with later photos and vegetation data. If monitoring reveals that treatments were not effective additional invasive plant treatments will be implemented.

2. Replant native species to priority sites along the river corridor, including native species of interest to Tribes

    1. Evaluating restoration success will occur on an annual basis for five years following active restoration and include monitoring of planted tree survivability, growth, success of seed broadcasting for upland species, and repeat photography. At the time of planting, data collections will include: tree height, canopy cover, diameter at breast height, planting method, and overall tree health. Each planted tree will be tagged with a unique number and GPS coordinates will be recorded. Four permanent photo points will be established per restoration site. Photos will be taken from points prior to active restoration for use as a baseline comparison with later photos. Photo point monitoring will be conducted on an annual basis. If restoration is not progressing towards a later successional stage, additional restoration treatments (i.e. seeding, planting, erosion control, invasive non-native plant control, etc.) may be implemented.

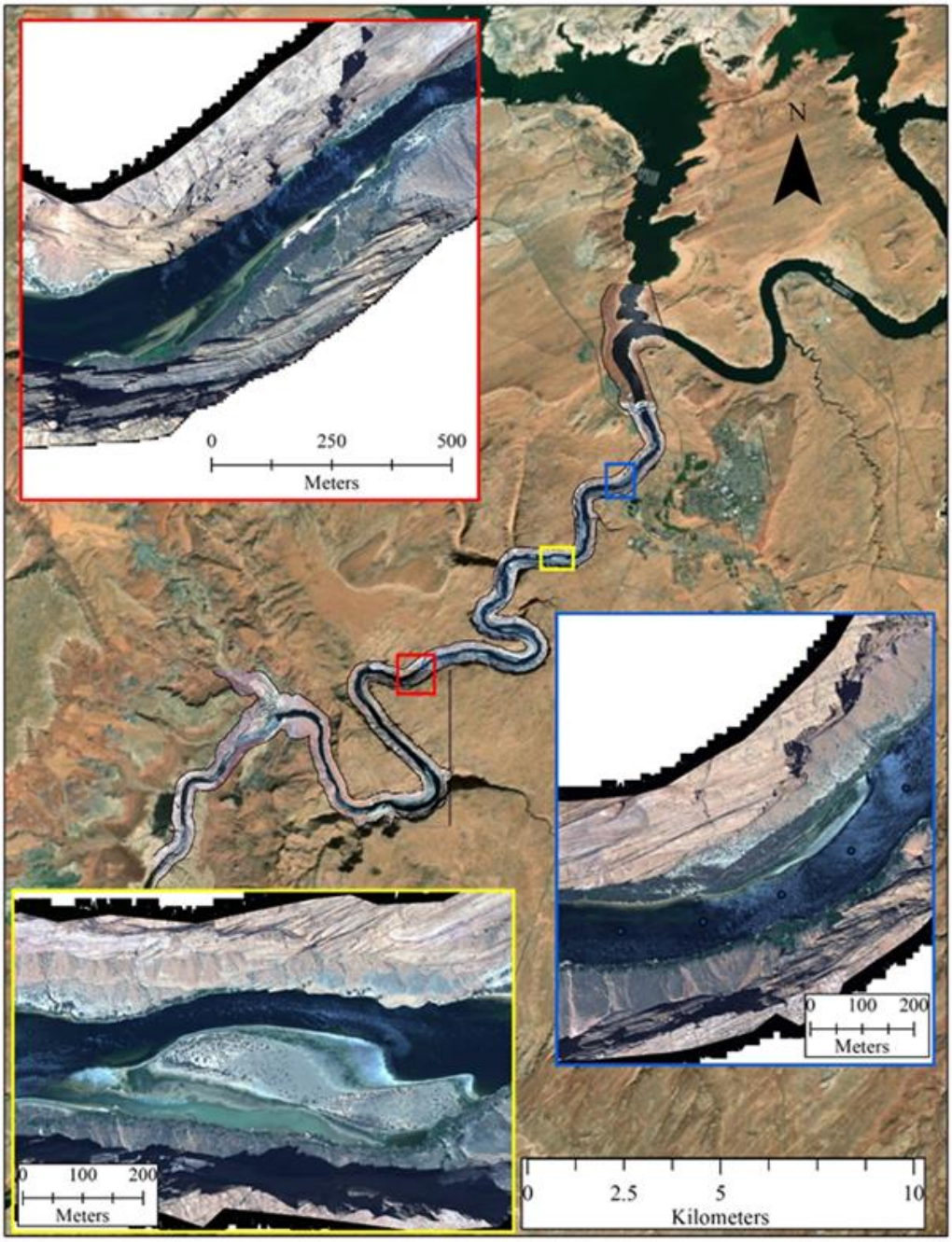
3. Remove vegetation encroaching on campsites
    1. Success of vegetation treatments to increase campable areas will be evaluated annually through pre- and post-treatment data collections. At each target campsite, 16 transects radiating from the geographic center of the primary common area of the campsite will be installed at compass bearings of 0, 23, 45, 68, 90, 113, 135, 158, 180, 203, 225, 248, 270, 293, 315, and 338 degrees (Cameron, 2014). GPS coordinates will be recorded for the center point. The following data will be recorded along each transect line pre- and post-treatment: distance to the first significant occurrence of vegetation that establishes the edge of the campable open space, rock obstructions limiting the campable barren core, or the 25K cfs flow line of the river (Cole and Hall, 1992). Subsequent visits to each campsite for continued monitoring will attempt to relocate the center point previously used for establishing transects. Treatment success will be evaluated annually for 2 years post-treatment and the need for additional treatments will be assessed. This monitoring will be coordinated with the Colorado River Management Plan (CRMP) campable area annual measurements and with the annual GCMRC sand bar and campsite monitoring approaches (GCMRC projects B.1, C.1) of the FY21-23 GCDAMP TWP.
4. Manage vegetation to assist with cultural site protection

    1. GCMRC project D.1 of the FY21-23 GCDAMP TWP provides a formal experimental design for evaluating if vegetation removal increases the probability of “preservation in place” of archaeological sites near HFE-sediment supplied sand bars, including site selection and pre- and post- treatment data collection. The monitoring methods for evaluating the effectiveness of the experimental vegetation treatments are described in detail in GCMRC Project D.1 and thus readers are referred to that document.

Funding and Budget

This project was approved for funding through the GCDAMP in the FY2021-FY2023 Triennial Budget. This project fits with the purpose and need for the LTEMP project, the environmental commitments specified in the LTEMP ROD, the August 2019 Memorandum from the Assistant Secretary, and finally and most importantly, with the intent of the Grand Canyon Projection Act to protect, mitigate and improve the resources downstream of the Glen Canyon Dam. It is allowed and intended to be funded as stated in the LTEMP ROD as an activity within the CRE; this project is mitigation identified in LTEMP as action within the CRE area influenced and affected by dam operations. Phases of the project are intended to start smaller with pilot projects and increase in size with each phase as more experience can be applied adaptively. Funding would be expected to be in the range of $200,000-$265,000 annually total for work within both NPS park units. The degree of funding allocated may vary to a degree between years based on the number of priority sites identified and their locations in particular reaches.

Figure 2. High priority restoration sites in GLCA. The sites are: blue square Ropes Trail at RM –14.5R; yellow rectangle is the Duck Slough at RM –12.0L, and the red square is Lunch Beach at RM –7.0L.



Suggested Citation for this Plan:
National Park Service. 2021. Long Term Experimental and Management Plan Experimental Vegetation Project Plan: For The Implementation Of The Vegetation Environmental Commitments From The LTEMP ROD in Glen Canyon National Recreation Area and Grand Canyon National Park Below Glen Canyon Dam.

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Attachment A: NPS Policies which guide this project

Selected sections of the 2006 NPS policies relevant to this project include:

4.0 The Service manages the natural resources of parks to maintain them in an unimpaired condition for present and future generations in accordance with NPS-specific statutes, including the NPS Organic Act and the National Parks Omnibus Management Act of 1998

4.1 Natural resources will be managed to preserve fundamental physical and biological processes, as well as individual species, features, and plant and animal communities. The Service will not attempt to solely preserve individual species (except threatened or endangered species) or individual natural processes; rather, it will try to maintain all the components and processes of naturally evolving park ecosystems, including the natural abundance, diversity, and genetic and ecological integrity of the plant and animal species native to those ecosystems. Just as all components of a natural system will be recognized as important, natural change will also be recognized as an integral part of the functioning of natural systems. By preserving these components and processes in their natural condition, the Service will prevent resource degradation and therefore avoid any subsequent need for resource restoration. In managing parks to preserve naturally evolving ecosystems, and in accordance with requirements of the National Parks Omnibus Management Act of 1998, the Service will use the findings of science and the analyses of scientifically trained resource specialists in decision-making.

4.1.5 The Service will reestablish natural functions and processes in parks unless otherwise directed by Congress. [….] The Service will use the best available technology, within available resources, to restore the biological and physical components of these systems, accelerating both their recovery and the recovery of landscape and biological community structure and function. Efforts may include, for example: removal of invasive non-native plant species, restoration of native plants and animals, etc.

4.4.2.4 Landscape and vegetation conditions altered by human activity may be manipulated where the park management plan provides for restoring the lands to a natural condition. Landscape revegetation efforts will use seeds, cuttings, or transplants representing species and gene pools native to the ecological portion of the park in which the restoration project is occurring. Where a natural area has become so degraded that restoration with gene pools native to the park has proven unsuccessful, improved varieties or closely related native species may be used.

Attachment B : GCD AMP FY21-FY23 Workplan

FIRST DRAFT. Bureau of Reclamation,

Glen Canyon Dam Adaptive Management Program Triennial Budget and Work Plan—Fiscal Years 2021–2023

C.7 and C.8. Experimental Vegetation Treatment

As described in the LTEMP Record of Decision, experimental riparian vegetation treatment is included as mitigation for dam operations within the Colorado River Ecosystem (CRE). This work is also listed as a priority in the Assistant Secretary Memo entitled Glen Canyon Dam Adaptive Management Guidance dated August 14, 2019. Vegetation treatment actions on NPS managed lands will be implemented by NPS consistent with NPS *Management Policies* (NPS 2006b) and consistent with the goals and objectives of LTEMP ROD. This will occur only within the CRE in areas that are influenced by dam operations. The NPS will work with tribal partners and GCMRC to plan, implement and evaluate a number of vegetation control and native replanting activities on the riparian vegetation within the CRE in Grand Canyon National Park and Glen Canyon National Recreation Area.

Principal elements of this experimental riparian vegetation proposal include:

1. Control nonnative plant species affected by dam operations, including tamarisk and other highly invasive species through various control methods;

2. Develop native plant materials for replanting through partnerships and the use of regional greenhouses;

3. Replant native plant species to priority sites along the river corridor, including native species of interest to Tribes;

4. Remove vegetation encroaching on campsites; and

5. Manage vegetation to assist with cultural site protection.

NPS will coordinate closely with GCMRC on this project. GCRMC projects C.4 and D.1 provide for the GCMRC's coordination with NPS and tribal partners in developing the scientific design, project site selection, implementation and monitoring protocols for the experimental vegetation treatments. During this triennial plan, NPS and GCRMC will develop and begin implementing experiments that evaluate techniques for campsite clearing (GRCA), native species replanting (GLCA), and invasive removal (GLCA, GRCA). Additionally, experiments developed in collaboration with GCMRC examining whether and how vegetation removal affects cultural resources and sediment dynamics will continue (see GCMRC TWP D.1). The intent of these evaluations is to identify the most cost-effective and environmentally-sensitive methods to achieve the LTEMP ROD principle elements. This will allow for an adaptive management approach to adopt the more efficient approaches over time.

Coordinated activities would include removal of selected plant species of concern at targeted sites and subreaches (e.g., live and dead tamarisk, arrowweed), replant of native species at targeted sites, and ongoing monitoring of treatment areas. GCMRC project D.1 also provides a formal experimental design for evaluating if vegetation removal increases the probability of "preservation in place" of archaeological sites near HFE-sediment supplied sand bars, including site selection and pre- and post- treatment data collection. This experiment provides the connection for how other LTEMP experiments such as spring, fall or extended HFEs relate to the vegetation work (as HFEs would be predicted to increase sediment at the strategic locations identified and then be available to be blown by wind to cover archeological sites). This experiment includes appropriate monitoring and controls to determine how much benefit to the covering of cultural sites actually accrues from such removals. Additional funds are available to provide outreach and coordination with Tribes by the NPS/GLCA for FY2020-21. In addition, GCMRC projects C.1, C.2, C.3 and L contribute to the NPS vegetation work in the following ways. Project C.1 provides riparian vegetation monitoring data between Glen Canyon Dam and river mile 240, which can be used to prioritize treatment areas and identify sources of native species for propagation. Project C.2 proposes to conduct manipulative experiments on hydrological tolerances of riparian species of interest, which can be used to inform species used for planting, locations of plantings in relation to surface flows, and anticipated responses of removed plants. Project C.3 proposes to develop predictive models of vegetation responses to flows using existing data from many sources, including data derived from the LTEMP non-flow vegetation experiments described here. These models can be utilized to develop planting and removal plans to increase treatment success. Project L will provide base maps for planning and navigating purposes, as well as spatial data sets that will contribute to project evaluation.

The project area is from Glen Canyon dam to Pearce Ferry. Project partners are the National Park Service (GLCA, GRCA), associated Tribes, GCMRC, Bureau of Reclamation, youth corps and volunteers. Project costs include project coordination, planning and administration costs (including an annual coordination and planning meeting for NPS, GCMRC and Tribes; GCMRC vegetation data processing and transfer to NPS), personnel costs (NPS seasonal and term biological technicians for field work, data entry and reporting; NPS term archeologist for on-site field work, GIS and data staff support; NPS tribal liaison to work with Tribes; NPS compliance staff; funding tribal staff for tribal engagement as partners in planning and executing the experiment and for tribal on-site field work), supplies (tools and herbicides, plant propagation, fuel for boat travel), and contracts, agreements and river support (cooperative agreement for greenhouse operation costs, river support for field work, youth crew agreement to support field work). NPS will explore additional sources of funding external to the program to assist in funding tribal partners.

Budget: GRCA FY21 = $168,850 FY22 = $166,143 FY23 = $195,272
GLCA FY21 = $43,000 FY22 = $84,000 FY23 = $67,000

Attachment C: Planning Notes for 2021-23 TWP

Based on planning meetings with GCMRC on February 14, 2020 and with Tribes and GMCRC on March 5, 2020, and discussions with the BAHG between February-April 2020 NPS has developed these planning notes:

1. **GRCA - For 2021 – 2023, invasive non-native plant treatments will continue at 20 or more sites per year**, vegetation treatments to increase campable areas will occur at 20 or more sites per year, cultural resource protection will occur at 6 or more sites per year, and native plant restoration actions at 1 to 3 sites per year. On 03/05/2020, we will be meeting with Tribes to discuss treatment site selection and culturally significant plant species for native plant restoration efforts. We will continue to engage tribal youth in project implementation.
2. **GCMRC and GRCA joint vegetation removal sites** – We are currently partway into the vegetation removal experiments, but since there was no high-flow experiment (HFE) in 2019, we will continue the experimentation and monitoring to evaluate combined effects of vegetation removal and HFEs through the 2021-23 TWP.
3. **GLCA continued vegetation project for 2021-2023**, the 2nd site (-12L) will have ongoing replanting of native species and maintenance work, with initial planning and preparations to initiate restoration at a 3rd site at -14.5R RM (Ropes Trail), which is a popular camping site; this site will be cleared in 2022 with initiation of native plantings, which will continue through 2023; final report will be prepared for 2nd Triennial Project and lessons learned developed in detail. There will be an increased effort to plant species that provide shade and are culturally significant, especially Goodding's willow and Fremont cottonwood. The Ropes Trail site will also include a joint project with BOR on terrace stabilization, which is a concern in the Glen Canyon reach. GLCA has seen greatly increased recreation impacts on the river corridor and will be initiating planning for additional camping sites including a potential overnight camp site at Lunch Beach. Currently this is a day-use only beach.
4. **Expanding the greenhouse experiments to study** the impacts of flow (hydrological conditions and burial by sediment) as well as non-flow (cutting) actions on arrowweed and seep willow would provide valuable information on arrowweed growth and performance under these conditions (as in the LTEMP treatments).

Attachment C: GRCA and GLCA Experimental Vegetation Treatment Progress Logs (FY2019 – FY2020)

River Mile	River Side	Site	Non-Native Plant Species	Control Method	Vegetation Species	Management Method to Assist with Cultural Site Protection	Vegetation Species	Removal Method for Vegetation Encroaching on Campsites	Native Plant Species Developed for Replanting
-7	L	Lunch Beach	TARA	Chemical					SAGO, VAST3, STPI
11.3	R	Soap Creek					TARA, PLSE	Manual	
24.5	L	RM 24.5L	LELA2	Chemical	TARA, PLSE	Manual	TARA, PLSE	Manual	
24.5	L	RM 24.5L	MENSPI	Manual					
38.7	L	Marthas Camp	LELA2	Chemical					
70	R	Basalt			TARA, PLSE	Manual	TARA, PLSE	Manual	
71.6	L	Cardenas	TARA	Chemical			PLSE	Manual	
71.6	L	Cardenas	LELA2	Chemical					
71.6	L	Cardenas	LELA2	Chemical					
72.7	L	Unkar Left					PLSE	Manual	
76.1	L	Nevills					PLSE	Manual	
77.1	L	Hance					PLSE	Manual	
93.8	L	Granite	ALMA12	Surveyed, not treated			PLSE	Manual	
99.6	L	Above Tuna Rapid	SARA3	Manual					
108.3	L	Ross Wheeler					PLSE	Manual	
122.8	R	RM 122.0R			TARA, PLSE	Manual	PLSE	Manual	

172	L	Mohawk	ALMA12	Chemical	TARA, PLSE	Manual	TARA, PLSE	Manual	
202.4	R	RM 202.0R					PLSE	Manual	
223.5	R	RM 223.0R			TARA, PLSE	Manual			
226.4	R	Truck Seat	ALMA12	Chemical			Various natives pruned	Manual	
243	R	RM 243.0R – RM 243.2R					PLSE	Manual	
243.2	R	RM 243.5R					PLSE	Manual	
248.7	R	Surprise Canyon					SAEX	Manual	
274.3	L	Grand Canyon Youth					Various natives pruned	Manual	

River Mile	River Side	Site	FY20 Non-Native Plant Species	Control Method	FY20 Vegetation Species	Management Method to Assist with Cultural Site Protection	Vegetation Species	Removal Method for Vegetation Encroaching on Campsites	FY20 Native Plant Species for Replanting	FY20 Replanting of Native Species at Priority Sites
-12	L	The Slough	TARA	Chemical						Restoration Site
-7	L	Lunch Beach	TARA	Chemical					SAGO, VAST3, STPI	SAEX, VAST3, AGUTK, CUPA
2	R	RM 2.0R	ELAN	Chemical						
2.8	R	Cathedral Wash	ELAN	Chemical						
5.9	R	RM 6.0R	ELAN	Chemical						
6.1	R	RM 6.0R	ELAN	Chemical						
8.1	R	Badger	ELAN	Chemical						
8.1	L	Jackass Canyon	ELAN	Chemical						
8.1	L	Jackass Canyon	ACRE3	Chemical						
8.3	R	RM 8.3R	ELAN	Chemical						
8.4	L	RM 8.4L	ELAN	Surveyed, no treatment						
16.6	R	Across from Hot Na	ELAN	Chemical						
18.4	R	RM 18.4R	ELAN	Chemical						
19.1	L	RM 19.1L	ELAN	Chemical						
19.9	R	RM 19.9R	ELAN	Chemical						
20.5	R	RM 20.0R	ELAN	Chemical						
21.4	R	RM 21.4R	ELAN	Chemical						
23.2	L	RM 23.2L	ELAN	Chemical						

24.5	L	RM 24.5L	TARA	Chemical	TARA	Chemical				
24.6	R	RM 24.6R	ELAN	Chemical						
26	R	Below Cave Springs Rapid	SARA3	Manual						
37.9	L	Tatahatso					SATR12	Manual		
38.7	L	Marthas Camp	LELA2	Surveyed, no treatment						
45.1	L	Lower End of Willie Necktie	COSE4	Surveyed, no treatment						
56.2	R	Kwagunt Marsh	SARA3	Manual						
57.6	L	RM 57.6L	COSE4	Surveyed, no treatment						
61.6	R	Above LCR Camp	ALMA12	Chemical						
61.8	L	Confluence Island	SARA3	Manual						
62.7	R	Crash Canyon	ALMA12	Chemical						
66.1	L	Palisades	ALMA12	Surveyed, no treatment						
66.8	L	Above Espejo	ALMA12	Surveyed, no treatment						

70	R	Basalt (Plot A)			PLSE	Chemical, Manual				
70	R	Basalt (Plot B)			PLSE	Manual				
70	R	Basalt			TARA	Chemical				
71.6	L	Cardenas	LELA2	Spray					SAGO	Potential restoration site
71.6	L	Cardenas	TARA	Spray						
71.6	L	Cardenas	ALMA12	Chemical						
71.6	L	Cardenas	ALMA12	Spray						
72.7	L	Unkar Left					ALMA12	Chemical		
76.1	L	Nevills (Treatment Plots A & B)	ALMA12	Chemical			PLSE	Manual		
76.5	L	Papago	ALMA12	Chemical						
77.1	L	Hance					PLSE	Manual		
81.7	L	Grapevine	ALMA12	Chemical						
93.8	L	Granite							SAGO, POFR2	Potential restoration site
108.3	L	Ross Wheeler					PLSE	Manual		
122.8	R	RM 122.0R	ALMA12	Chemical	PLSE	Chemical				
132	R	Stone Creek 1	ALMA12	Surveyed, no treatment						
143.8	R	Kanab	ALMA12	Surveyed, no treatment						
172	L	Mohawk	ALMA12	Chemical	PLSE	Chemical				
172	L	Mohawk			PLSE	Manual				

202.4	R	RM 202.0R					PLSE	Manual		
223.5	R	RM 223.0R	ALMA12	Chemical	TARA	Chemical				
226.4	R	Truck Seat	ALMA12	Chemical						
243	R	RM 243.0R – RM 243.2R					TRTE	Manual		
243.2	R	RM 243.5R					ALMA12	Chemical		Potential restoration site
243.2	R	RM 243.5R					TARA	Chemical		
248.7	R	Surprise Canyon					SATR12	Manual	SAGO, FRVE2	Potential restoration site
269.9	R	Travertine Grotto							SAGO	
274.3	L	Grand Canyon Youth					TRTE	Manual	SAGO	Potential restoration site
274.3	L	Grand Canyon Youth					TRTE	Manual		
274.3	L	Grand Canyon Youth					TARA	Chemical		
275.2	L	Columbine Falls							SAGO	

Attachment D: GRCA and GLCA Experimental Vegetation Treatments - Proposed Sites and Actions (FY2021)

River Mile	River Side	Site	FY21 Non-Native Plant Species	Control Method	FY21 Vegetation Species	Management Method to Assist with Cultural Site Protection	FY21 Vegetation Species	Removal Method of Vegetation Encroaching on Campsites	FY20 Develop Native Plant Species for Replanting	FY2020 Replant Native Species at Priority Sites
-12	L	The Slough	TARA	Chemical						Restoration Site
-7	L	Lunch Beach	TARA	Chemical						Restoration Site
0.2	R	Below Lees Ferry	SARA3	Manual						
1.1	R	Paria Beach	SARA3, TARA	Manual, Chemical					SAGO, POFR2, SAEX	Restoration Site
2	R	RM 2.0R	ELAN	Manual						
2.8	R	Cathedral Wash	ELAN	Chemical						
5.9	R	RM 6.0R	ELAN	Chemical			TARA, PLSE	Manual, Chemical		
6.1	R	RM 6.0R	SARA3	Manual						
8.1	R	Badger	ELAN	Chemical			TARA, PLSE	Manual, Chemical		
8.1	L	Jackass Canyon	ACRE3	Chemical			TARA, PLSE	Manual, Chemical		
8.3	R	RM 8.3R	ELAN	Manual						
8.4	L	RM 8.4L	ELAN	Manual						
10.9	L	RM 10.9L	SARA3	Manual						
11.3	R	Soap Creek			TARA, PLSE	Chemical	TARA, PLSE	Chemical		
16.6	R	Across from Hot Na	ELAN	Chemical						
18.4	R	RM 18.4R	ELAN	Chemical						

19.1	L	RM 19.1L	ELAN	Chemical						
19.9	R	RM 19.9R	ELAN	Chemical						
20.5	R	RM 20.0R								
21.4	R	RM 21.4R	ELAN	Manual						
23.2	L	RM 23.2L	ELAN	Manual						
24.5	L	RM 24.5L	LELA2	Chemical	TARA, PLSE	Chemical	TARA, PLSE	Manual, Chemical		
26	R	Below Cave Springs Rapid	SARA3	Manual						
37.9	L	Tatahatso	SARA3	Manual			TARA, PLSE	Manual, Chemical		
45.1	L	Lower End of Willie Necktie	COSE4	Manual						
46.9	R	Above Saddle	SARA3	Manual						
48.5	L	Below Saddle	SARA3	Manual						
48.8	R	RM 48.8R	SARA3	Manual						
50.3	R	RM 50.3R	COSE4	Manual						
50.7	L	RM 50.7L	SARA3	Manual						
51.2	R	RM 51.2R	SARA3	Manual						
52	R	Above Little Nankoweap	SARA3	Manual						
52.1	R	Little Nankoweap	SARA3	Manual			TARA, PLSE	Manual, Chemical		
53.1	R	Upper Nankoweap	SARA3	Manual			PLSE	Chemical		
53.4	R	Main Nankoweap	SARA3	Manual			PLSE	Chemical		
53.5	R	Lower Nankoweap	SARA3	Manual			PLSE	Chemical		
55.9	R	Kwagunt Marsh	SARA3	Manual						
56.2	R	Kwagunt (RM 56.2 - RM 56.6)	SARA3	Manual			PLSE	Chemical		
57.6	L	RM 57.6L	SARA3	Manual						
61.6	R	Above LCR Camp	ALMA12	Chemical						
61.8	L	Confluence Island	SARA3	Manual						
61.8	L	LCR Day Use Area	SARA3	Manual						

62.7	R	Crash Canyon	ALMA12	Chemical						
66.1	L	Palisades	SARA3	Manual			PLSE	Chemical		
66.6	L	Below Palisades	SARA3	Manual						
66.8	L	Above Espejo	ALMA12	Chemical						
69	L	Tanner Rapid Left								
69	R	Tanner Rapids Right	SARA3	Manual						
69.3	L	Below Tanner Rapid	TRTE	Manual						
70	R	Basalt	ALMA12	Chemical	TARA, PLSE	Chemical	TARA, PLSE	Chemical		
70.8	R	Above Cardenas	SARA3	Manual						
71.4	R	No Name 71.0 (Cardenas Marsh)	SARA3	Manual						
71.6	R	Across from Cardenas	SARA3	Manual						
71.6	L	Cardenas							SAGO	Potential restoration site
72.4	R	Upper Unkar	ALMA12	Chemical			TARA, PLSE	Chemical		
72.7	L	Unkar Left	ALMA12	Chemical			PLSE	Chemical		
76.1	L	Nevills	ALMA12	Chemical			PLSE	Chemical		
77.1	L	Hance					PLSE	Chemical		
81.7	L	Grapevine	ALMA12	Chemical						
93.8	L	Granite							SAGO, POFR2	Potential restoration site
98.7	R	Crystal	ALMA12	Chemical						
99.6	L	Above Tuna Rapid	SARA3	Manual						
99.6	L	Above Tuna Rapid	LELA2	Chemical						
99.7	R	Tuna Creek	SARA3	Manual						
108.1	R	Hotauta					PLSE	Chemical		
108.3	L	Ross Wheeler					PLSE	Chemical		

119.1	L	Across from Big Dune	SARA3	Manual						
122.8	R	RM 122.0R	ALMA12	Chemical	PLSE	Chemical	PLSE	Chemical		
132	R	Stone Creek 1	ALMA12	Chemical						
136.9	R	Deer Creek Falls	SARA3	Manual						
136.9	R	Deer Creek Falls	ALMA12	Chemical						
137.8	L	Backeddy	LELA2	Chemical			PLSE	Chemical		
137.9	L	Backeddy	SARA3	Manual						
141.1	L	Below Keyhole	SARA3	Manual						
143.8	L + R	Kanab (RM 143.8 - RM 144.8)	ALMA12	Chemical						
145.9	L	Above Olo	SARA3	Manual						
172	L	Mohawk	ALMA12	Chemical	TARA, PLSE	Chemical	TARA, PLSE	Chemical		Potential restoration site
176.5	R	Below Redslide	SARA3	Manual						
183	R	Lower Chevron					PLSE	Chemical		
188.8	L	Below Lower Whitmore	SARA3	Manual						
193.3	L	RM 193.3L	SARA3	Manual						
194.6	L	Hualapai Acres	SARA3	Manual			PLSE	Chemical		Potential restoration site
197	R	Froggy Fault	ALMA12	Chemical						
197	R	Across Froggy Fault	SARA3	Manual						
202.4	R	RM 202.0R					PLSE	Chemical		
206.4	L	Above Indian Canyon	SARA3	Manual						
206.5	R	Above Indian Canyon Right	ALMA12	Chemical						
206.5	R	Above Indian Canyon Right	SARA3	Manual						
209	L	Granite Park								Potential restoration site
209.7	L	Below Granite Park	SARA3	Manual						

223.5	R	RM 223.0R	ALMA12	Chemical	TARA, PLSE	Chemical				
225.2	L	Above Diamond	SARA3	Manual						
226.4	R	Truck Seat	ALMA12	Chemical						
226.4	R	Truck Seat	SARA3	Manual						
239.6	L	RM 239.6L	SARA3	Manual						
242.6	R	RM 242.0R					PLSE	Chemical		
243	R	RM 243.0R – RM 243.2R					PLSE	Chemical		
243.2	R	RM 243.5R	ALMA12	Chemical			See above			Potential restoration site
248.7	R	Surprise Canyon	SATR12	Manual			PLSE	Chemical	SAGO, FRVE2	Potential restoration site
269.9	R	Travertine Grotto					PLSE	Chemical	SAGO	
274.3	L	Grand Canyon Youth	TRTE	Manual			TARA, PLSE	Chemical	SAGO	Potential restoration site
275.2	L	Columbine Falls							SAGO	