Laguna Riparian Enhancement Project

Laguna Division
Lower Colorado River

Natural Channel Design, Inc.

December 2007

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OVERVIEW

The Laguna Riparian Habitat Enhancement Concept presents a conceptual plan for improving native riparian vegetation and associated habitats within the Laguna Reach along the lower Colorado River (LCR). Various entities including the Bureau of Reclamation (Reclamation) are actively involved in protecting and restoring habitats along the lower Colorado River. This concept is intended to provide a basis for efforts to enhance or restore habitats within the Laguna Division for a variety of valuable fish and bird species and to stimulate discussion on ways to meet these goals.

The concept described does not address water rights issues.

The goal of the concept is to replace existing low-quality habitats provided by dense thickets of tamarisk with more productive, diverse communities of native riparian plant species. The concept design is driven by the following objectives:

- Maximize high quality native riparian plant communities and associated wildlife habitats.
- Maximize benefits from water required
- Minimize maintenance
- Protect existing infrastructure (canals, desilting basin, spoil area)
- Protect and/or enhance existing riparian habitat in “old river channel” and Mittry Lake

EXISTING CONDITIONS

The Laguna Riparian Habitat Enhancement Concept site lies within the Laguna Division of the LCR, a stabilized and highly modified reach of the LCR between Laguna Dam (RM 43) and Imperial Dam (RM 49). Laguna Dam was constructed in 1909 to provide a consistent delivery of water from the LCR to the growing agricultural industry. High sediment loads prior to the construction of Hoover Dam contributed to the rapid siltation upstream of the dam. Imperial Dam was completed in 1938 and allows delivery of water through the All-American Canal and the Gila Main Gravity Canal. The majority of the Colorado River is diverted for agricultural or domestic purposes at Imperial Dam, with the exception of sluicing flows and a small inflow into Mittry Lake, a water body along the eastern edge of the area. Mittry Lake was dredged by Reclamation and provides significant recreational opportunities, as well as valuable riparian and marsh habitat.

The Laguna desilting basin is located within this reach, downstream of the Imperial Dam. Sediment derived from the Parker, Palo Verde, Cibola, and Imperial divisions accumulates at the upstream face of Imperial Dam, and at the headworks for the All-American Canal and the Gila Gravity Main Canal. The sediment is then sluiced or dredged into the Laguna settling basin where suspended materials are removed from the water column. After deposition in the settling basin the sediment is dredged and disposed of in the adjacent areas. The Laguna Reservoir Restoration Project located at the upstream side of Laguna Dam provides the potential to capture and store up to 1,500 acre-feet of water below Imperial Dam and release them to meet water delivery requirements downstream.

The concept design area includes approximately 730 acres and lies between the Laguna Dredge Disposal Area and the Old River Channel area south of the Gila Canal Wasteway (Figure 1). The concept is designed to integrate and complement the existing infrastructure and uses within the Division.

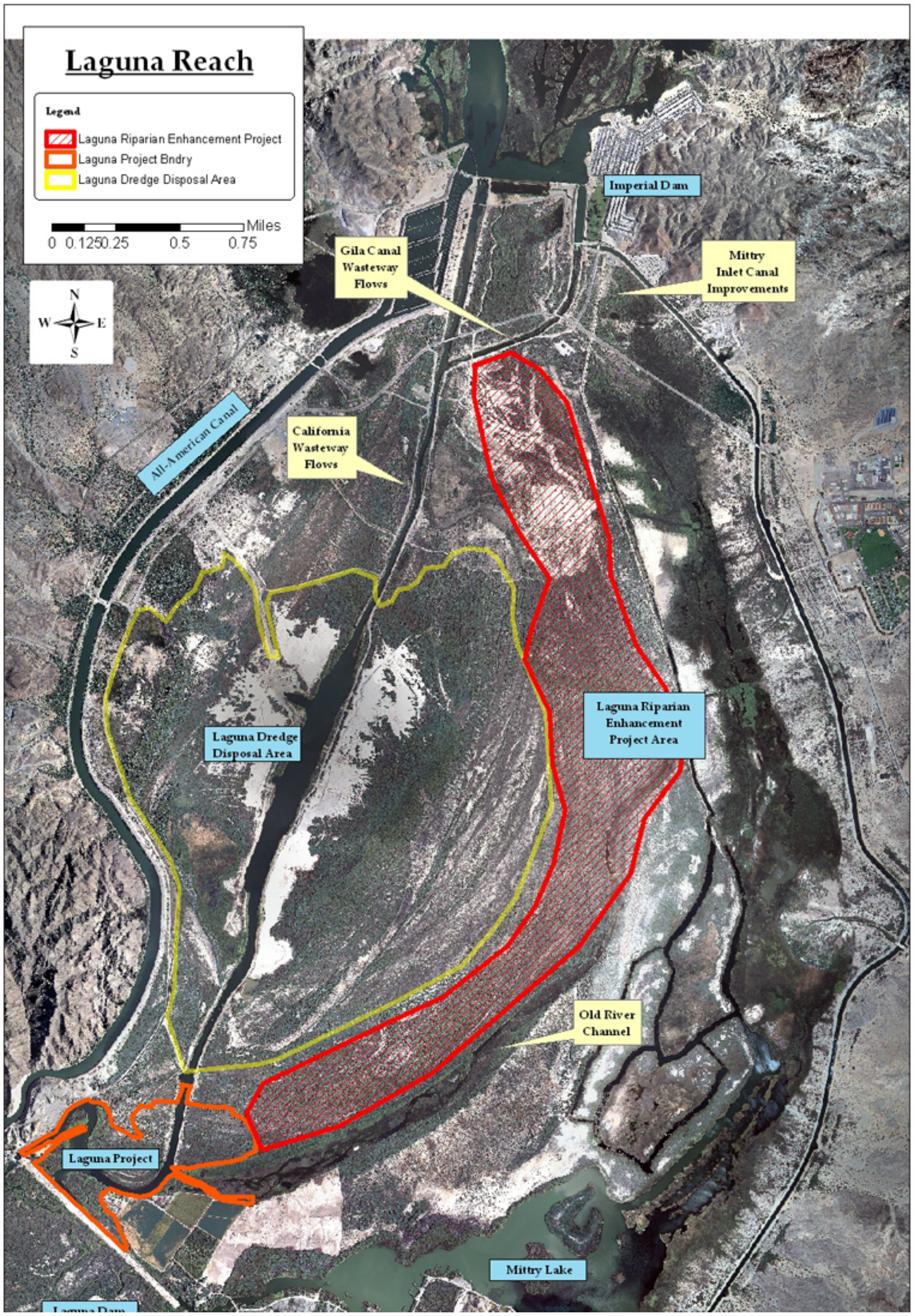

Figure 1 Location map.

The project is located between Imperial and Laguna Dams on the Lower Colorado River and occupies approximately 730 acres between the Laguna Dredge Discharge Area and the Old River Channel.

PREVIOUS PLANNING EFFORTS

Opportunities for restoration of the habitats along the Lower Colorado River in the Laguna Division have been discussed for several years. A report titled Laguna Habitat Restoration Concept was prepared by CH2M-Hill for the Bureau of Reclamation in the late 1990s. This concept plan describes a river channel and associated wetlands excavated within the division and fed by dedicated flows through the Mittry Lake canal. A series of "semi-permeable barrier" water control structures would temporarily impound water. Stands of invasive tamarisk would be replaced by native vegetation.

A variety of restoration opportunities have been discussed to the Laguna Division and an informal group, the Laguna Restoration Planning Group, meets periodically. The group identified three approaches to restoration of the area: Managed Flow Through, Managed Flow Cells, and Natural Flow Through. Each of these approaches envisioned a single channel system with overbank areas that could be inundated periodically. The approaches vary primarily in methods of water application and management. These three approaches were described in the 6/13/06 meeting minutes of the planning group.

1. ***Managed Flow Through:*** *A pilot channel would be created and banks on either side would be contoured, approximately 100-200 feet across. Pulse flows would be used to raise water surface out of pilot channel and inundate the contoured banks. The pilot channel would follow the existing alignment of the Old River Channel, a distance of 2-4 miles. It is not the intent to cause scouring flows.*
2. ***Managed Flow Cells:*** *This concept is similar to the Managed Flow Concept, with the addition of weirs at periodic intervals along the channel. Instead of water surface being raised to inundate the contoured banks, the weirs would cause flow to pond and wet the contoured bank surface. This concept would also follow the Old River Channel alignment.*
3. ***Natural Flow Through:*** *This concept would release water at a high point and let the flow follow its own path. Areas considered for this concept is land between the Old River Channel and the Laguna Settling Basin. There are a number of small channels in this area and flows could be released at a number of points to create a braided stream effect.*

These approaches were evaluated to provide a starting point for the concept planning.

Each approach has strengths. The excavation of an appropriate channel and overbank through the project in the first two approaches would facilitate the removal of the dense tamarisk thickets and speed the active or passive establishment of native riparian species. All three approaches would maintain sufficient soil moisture through upstream discharges of Colorado River water. The system of impoundments described in the Managed Flow Cells approach would reduce the water volume requirements. The alignments of the first two alternatives are limited to the Old River Channel. The Natural Flow Through alternative relies on natural processes to create a new channel network, a process that could take considerable time and, given the limited flows available, produce less than optimum topography.

It was determined that a modified Managed Flow Cells alternative would provide the best approach to effectively meet project objectives. This was also reinforced by the successes of a similar strategy in the downstream Yuma East Wetlands project. In the end, this alternative was modified to include a multi-channel network to spread waters over a wider area and maximize the potential for high-quality riparian habitats.

CONCEPT DESCRIPTION

The project will take place in the area between the Laguna desilting basin and the Old River Channel and above the planned restoration of the Laguna Reservoir. The restoration area is approximately 3.5 miles in length and contains 730 acres. The concept includes a multi-channel network divided into 4 reaches by low "drop-log" water structures. The structures restrict flows to allow water to be temporarily impounded to an elevation to wet and flush overbank areas. Water would be supplied to the system from the Gila Canal Wasteway in order to maximize the area to be restored. The concept includes the potential to supply additional flows to the Old River Channel to enhance the habitats there. At the downstream end, the channel network would link to the Laguna Reservoir Restoration Project where project waters could be temporarily stored before being delivered to meet downstream obligations. This would allow the most efficient management of water.

The concept includes the following elements:

- Removal of existing non-native tamarisk;
- Excavation of a multi-channel network, wetlands, and associated flood terraces;
- Installation of "stop-log" water control structures;
- Revegetation of all project areas with native riparian plant species; and
- Modification of Gila Canal Wasteway to provide flows to the area.

Table 1 Project reach lengths

	REACH				
	1	2	3	4	Totals
Reach Length (miles)	0.90	0.92	1.01	0.69	3.53
Reach Areas (acres)	193	262	156	119	730
Wetted channel length (miles)	2.99	3.95	2.51	2.01	11.45
Wetted channel length (ft)	15,764	20,856	13,246	10,593	60,459

It should be noted that the total area of riparian habitat enhancement could be substantially increased if the eastern portion of the Laguna desilting basin spoils area were included. This area is not currently being used to store spoils and appears to have the appropriate topography to be included in this project.

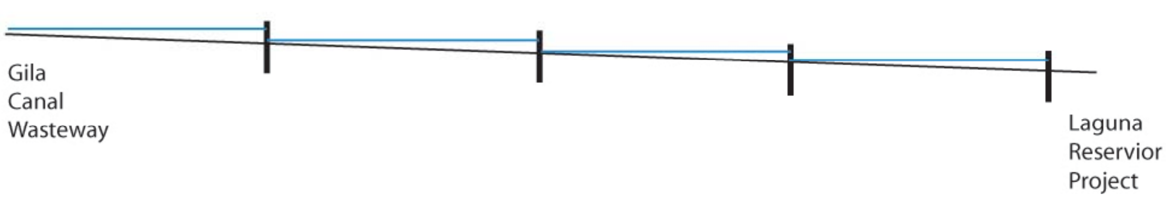

Figure 2 Channel profile

The concept design reach is divided into 4 reaches each separated by a low water control structures creating a stair step profile as shown in this graphic.

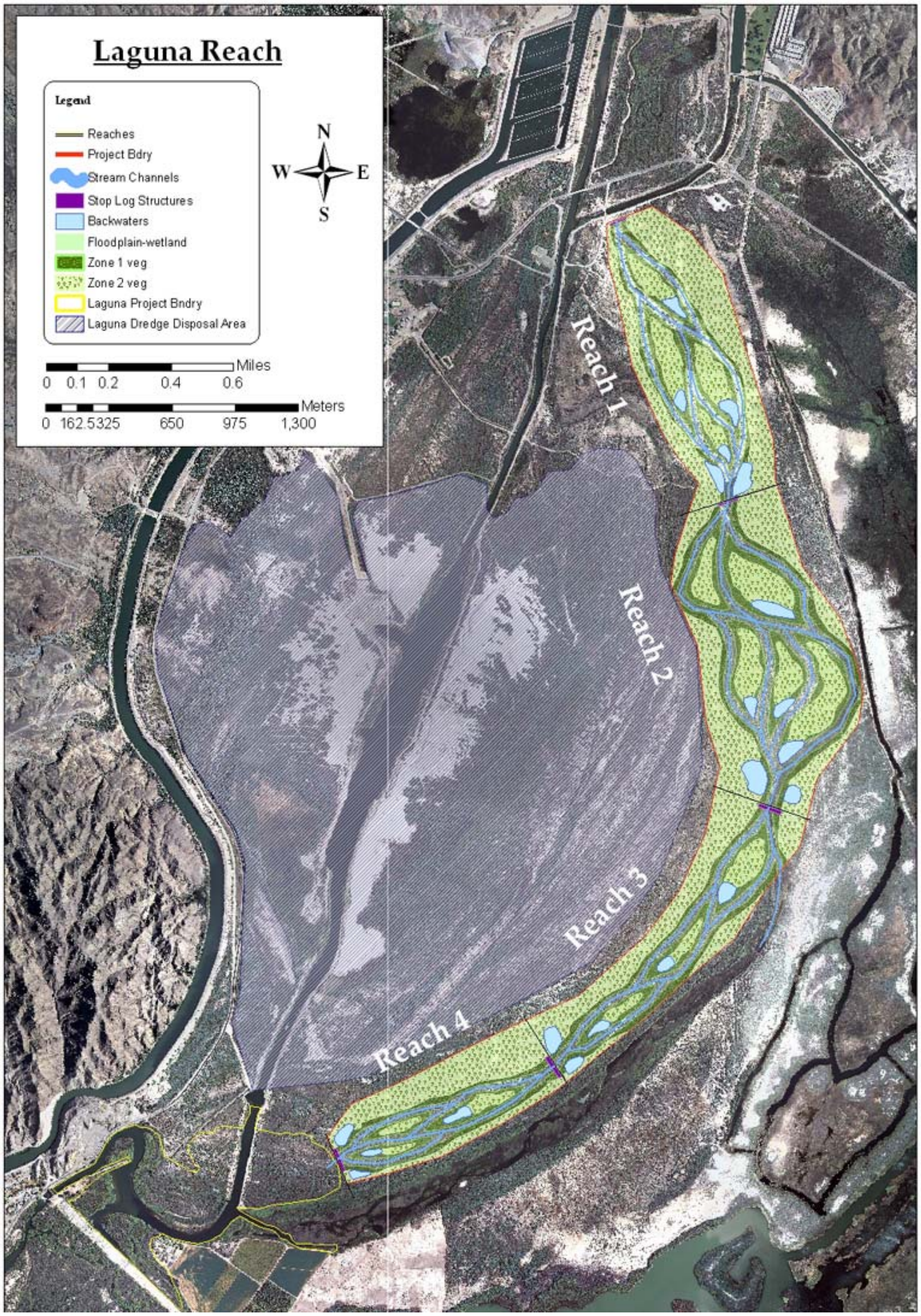

Figure 3 Laguna Riparian Enhancement Project

This graphic presents the channel form and alignment as well as riparian planting zones. Note that in Reach 3 base and pulse flows can be diverted into the Old River Channel to enhance native habitats there.

PHYSICAL COMPONENTS

The physical components of the concept include a multi-channel network within the project area. Each channel would consist of five vegetation zones; wetted channel, floodplain, low terrace, high terrace, and backwater wetland. Each zone is aligned roughly parallel to the stream channel and differentiated by increasing elevations above and lateral distance away from the central channel. Each zone is characterized by differing soil moistures and supports different and unique native riparian habitats (Figures 4 & 5).

Wetted channel: The central channels are approximately 30 feet in width with a maximum depth of 3 feet and a mean depth of 2 feet. These channels convey base flows and are periodically flooded to depths of 5 or 6 feet during pulse flows.

Floodplain: The floodplain varies in width between 20 and 60 feet on each side of channel with an average width of 40 feet. Banks slope gently from channel edge upward to next zone. Elevation above channel bed ranges from 3 to 5 feet with a mean elevation of 4 feet. Periodically inundated by pulse flows slowly drying due to infiltration and ET.

Low Flood Terrace: This zone width varies from 20 to 80 feet with average width of 50 feet on each side of channel. Slopes gently from channel edge upward to next zone. Elevations above channel bed range from 5 to 7 feet with an average elevation of 6 feet.

High Flood Terrace: The elevation of this zone ranges from 7 feet to 10 feet above channel bed with a average elevation of 8 feet. The zone includes the remainder of the project area. Slopes gently from channel edge upward from lower zones.

Backwater wetland: Backwater areas can be created along the wetted channels. These areas will be excavated below channel bed elevation to provide more persistent open water areas between pulse flows.

RIPARIAN HABITATS

Each zone will support a distinct riparian plant community and associated habitats.

Wetted channel Zone: (~41 acres) These channels are expected to contain open water of varying depths and areas and support herbaceous sedge/rush/bulrush communities.

Floodplain Zone: (~ 124 acres) (Baccharis-willow zone) These areas will be periodically inundated by pulse flows and maintain relatively high soil moisture. This soil moisture and proximity to the channel bed elevation will support a variety of native herbaceous species as well as supple woody species such as *Salix exigua* and *Baccharis salicifolia*.

Low Flood Terrace: (~ 158 acres) (Cottonwood-willow zone): The slightly higher elevation of this terrace will result in less inundation and a deeper groundwater table. However, it is expected to support trees species such as Fremont Cottonwood (*Populus fremontii)* and Gooddings willow (*Salix Gooddingii)* as well as native herbaceous and shrub species.

High Flood Terrace: (360 acres) (Mesquite-quailbush zone): These higher areas will still be connected to available groundwater and support more xeric native community including Honey mesquite (*Prosopis glandulosa*), Screwbean mesquite (*Prosopis pubescens*), quailbush (*Atriplex lentiformis*), and other native xeric herbaceous and shrub species.

Backwater wetlands: (~37 acres) These lower and more persistent open water areas support cattails (*Typa ssp*), bulrush (*Scirpus ssp*) and other deeper water wetland species. Adjacent floodplain and low flood terrace habitats can supply additional structure and canopy to wetland areas (Figure 5).

See Table 2 for habitat areas by reach.

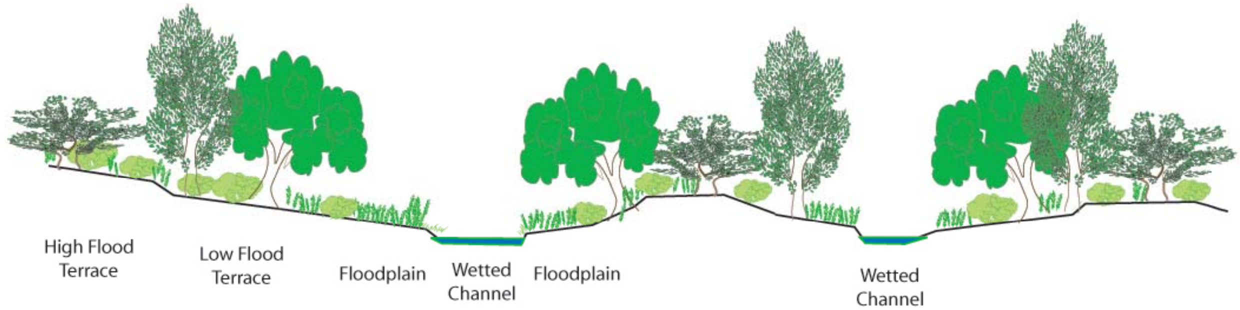

Figure 4 Typical Cross-section with riparian plant zone.

This graphical presents a typical cross-section showing two wetted channels and the associated floodplain, and terrace zones. The graphic is not to scale.

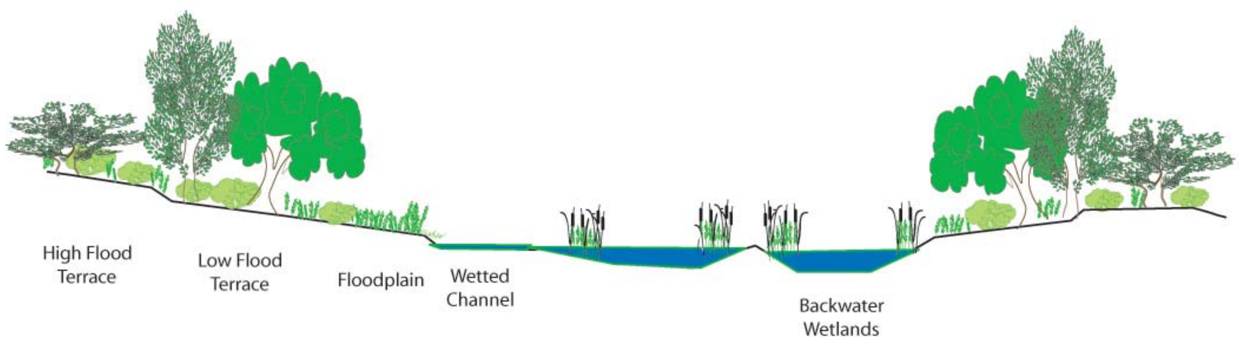

Figure 5 Typical channel-backwater wetland cross-section

The graphic presents a typical cross-section showing wetted channel and associated backwater wetlands. The wetlands are slightly below channel grade supporting open water habitats between pulse flows.

Table 2 Design channel dimensions

	Elev	Width	Side slope
Bottom channel width	0	10	NA
Wetted Channel Zone	2.5	30	4
Floodplain Zone	5	110	16
Low Flood Terrace Zone	7.5	300	38
High Flood Terrace Zone	10	450	30

Table 3 Riparian Habitat Zones

	REACH 1	2	3	4	Totals
Reach Length (miles)	0.90	0.92	1.01	0.69	3.53
Reach Areas (acres)	193	262	156	119	730
Channel length (miles)	2.99	3.95	2.51	2.01	11.45
Channel length (ft)	15,764	20,856	13,246	10,593	60,459
Wetted Channel Zone					
Average Zone Width (feet)	30				
Stream channel Area (acres)	10.86	14.36	9.12	7.3	41.64
Floodplain Zone	*Baccharis-willow*				
Average Zone Width (feet)	80				
Floodplain area (acres)	28.27	49.91	27.93	18.39	124.5
Low Flood Terrace Zone	*Willow-cottonwood tree*				
Average Zone Width (feet)	100				
Low Flood Terrace (acres)	35.49	60.59	36.95	25.03	158.06
High Flood Terrace Zone	*Mesquite-quailbush*				
Average Zone Width	variable				
Total Area (acres)	109.98	119.66	72.41	61.41	360.55
Backwater wetland Zone	*Bulrush-cattail-sedge*				
Backwater areas (acres)	10.4	13.94	7.98	4.67	36.99
Total Zone Areas by Reach (acres)	195.00	258.46	154.39	116.80	721.74

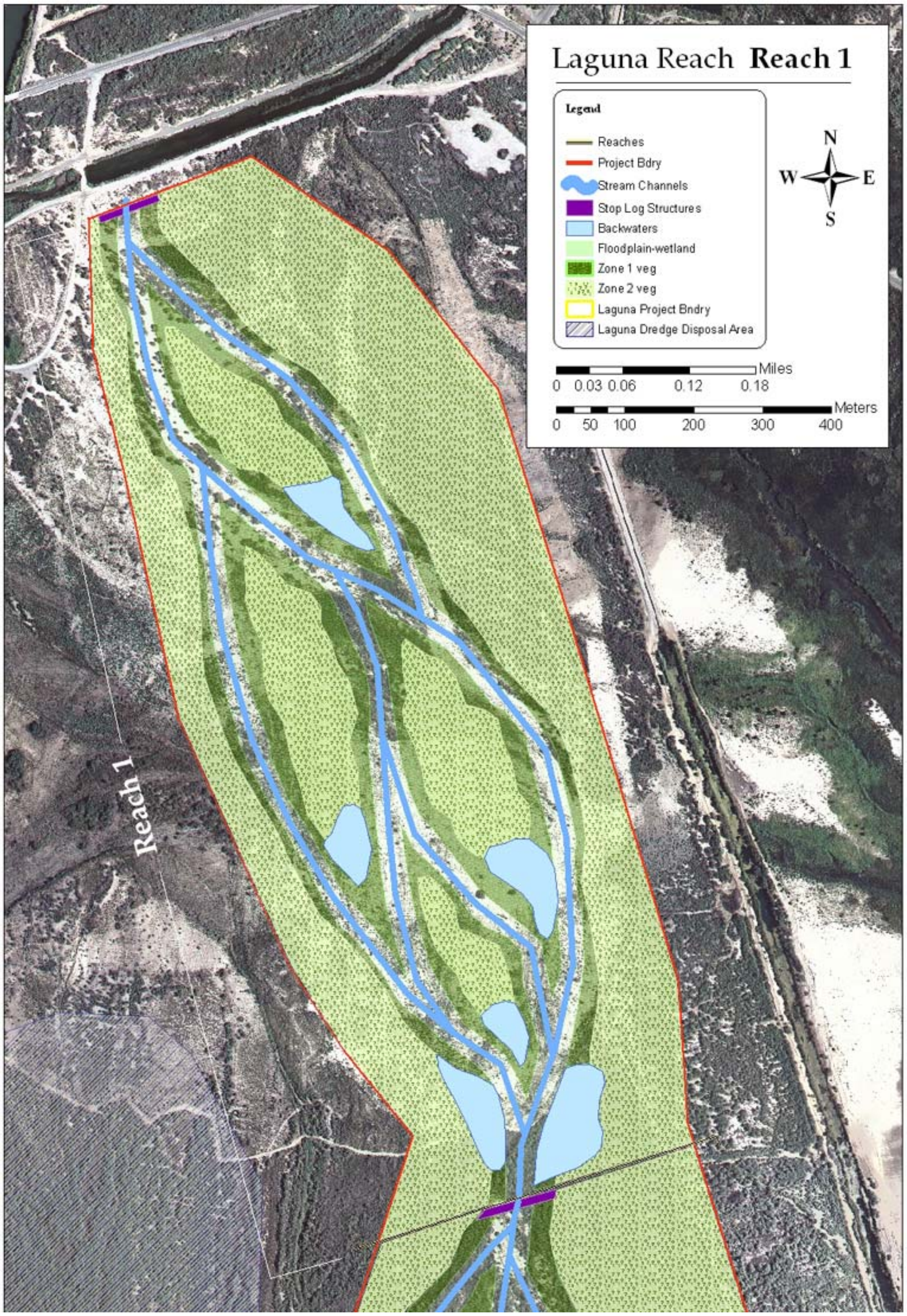

Figure 6 Reach 1

This graphic presents the conceptual shape and alignment of channels in Reach 1. Riparian planting zones are shown at varying elevations and distances from the wetted channel.

WATER MANAGEMENT

Water is an essential ingredient to the success of any riparian habitat restoration. The following section addresses issues involved with water flows and their management.

Water Rights

This concept does not directly address the issue of water rights. It assumes that Colorado River water can be physically conveyed from Imperial Dam to the project through the Gila Canal Wasteway in sufficient quantities to support project components. It also acknowledges the legal framework surrounding the entitlement of Colorado River and assumes that the water will be delivered on a voluntary basis and accounted for under present law.

Sources and Conveyance

There are two potential sources and conveyances for project water; the canal to Mittry Lake and the Gila Canal Wasteway. The Gila Canal Wasteway is the preferred conveyance as it allows water delivery higher in the division and potentially allows larger pulse flows.

Elevation Control

The stream channel elevation drops approximately 30 feet over the project area. The concept envisions 4 low drop-log water control structures, each with a height of 7-8 feet, installed in the excavated channel. These structures allow water to be temporarily impounded in the areas upstream. Water surface elevations can be adjusted using the “stop-logs” to optimize the inundation. When water surface elevations rise above the stop-logs, flows are allowed to pass to the next reach.

Actual, number, spacing, and height of water control structures may be modified during the design process.

Conceptual Flow Regime

Native riparian vegetation requires not only a shallow, dependable groundwater table but periodic overbank flows that replenish soil moisture, flush salts, and provide disturbance in floodplains and terraces. The project area currently supports dense thickets primarily dominated by tamarisk (*Tamarisk spp*). This suggests that groundwater levels are relatively shallow and dependable. This is reinforced by the existence of native riparian vegetation in the adjacent Old River Channel.

Base flows

A moderate base flow of 30-50 cfs is recommended in this concept design. This flow would maintain groundwater elevations, reduce the growth of restrictive woody species, and minimize the production of mosquitoes. Based on a 365 day period, these flows would require an annual volume of water 20,000 and 35,000 acre-feet. However, base flows would not be required during overbank pulse flows, reducing this volume by 3,000 to 5,000 cfs. Flows would be recaptured in the downstream Laguna Reservoir and available for downstream delivery obligations.

Overbank flows

Periodic pulse flows would be introduced to the project area and impounded in each reach by the stop-log structures. The flows would temporarily inundate the channel and adjacent floodplains supporting the associated vegetation. The flows are expected to increase groundwater elevations sufficiently to support the cottonwood-willow and mesquite-quailbush zones. Based on experience in other projects, some periodic inundation of the cottonwood-willow zone may also be desired. Water volumes required to inundate the channel and floodplain in each reach during a single pulse flow are presented in Table 3.

Flow Management

Discharge rates and volumes for both base and pulse flows could be managed to optimize the benefits to the riparian communities while minimizing water use. Base flows could be varied seasonally to optimize riparian and wetland vegetation. Pulse flows could be managed to inundate one reach at a time or all reaches sequentially depending on vegetation needs and the most efficient water management. For example, Reach 1 could be inundated for a short period of time, then the waters allowed to enter the next reach and the next until finally collecting in the Laguna Reservoir. The maximum volume needed to fill a single reach is 132 acre-feet in Reach 3 (Table 4). This operational scheme would require active management of the drop-log structures to transfer water.

An alternative would be to flood all reaches simultaneously allowing the ponded flows to slowly discharge over a period of time through the drop-log structures. The structures would control base elevation to provide open water and wetland habitats. The discharge volume under this scenario for each pulse flow remains less than 400 acre-feet. In both scenarios, the pulse flows would collect in the Laguna Reservoir and be available for downstream deliveries.

The timing and frequency of pulse flows may be best determined through adaptive management. Water requirements and pulse flows would be more frequent during the hotter growing season and less frequent during winter months. Assuming pulse flows are required to flood the cells every two weeks during the hottest 6 months and monthly during the remainder of the year, the total discharge requirement is less than 7,000 acre-feet annually. These flows will be recaptured in the Laguna Reservoir upstream of Laguna Dam.

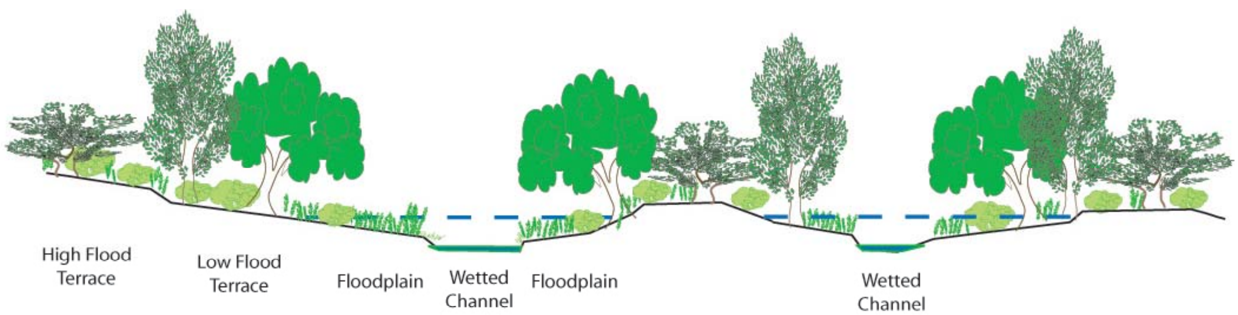

Figure 7 Pulse flow inundation

Periodic pulse flows would inundate the wetted channel, floodplain, and low flood terrace increasing soil moisture, flushing salts, and introducing disturbance. The dashed line represents the pulse flow water surface.

Conceptual Water Balance

The water use of existing and conceptual vegetative communities have not been quantified at this conceptual stage. Native riparian vegetation utilize water in uptake and evapo-transpiration. However, the existing dense stands of tamarisk represent an existing use of water. Variability in density, environmental conditions, and other variables, makes it difficult to directly calculate the uptake and evapo-transpiration rates of these two communities. For the purposes of this concept it is assumed that the water requirements of the native riparian vegetation will be roughly equal to the uses of the existing vegetation.

The restoration concept includes some areas of open water that may increase evaporation. However, these open water areas backwaters are relatively small. Elevated water surfaces and ponding due to periodic pulses may increase infiltration volumes. However, infiltration will contribute to groundwater flows that are expected to collect in the Laguna Reservoir and be available for downstream deliveries.

Flows to Old River Channel

The Old River Channel lies adjacent to the concept channels. This area supports native riparian vegetation supported primarily by groundwater. The concept includes a conveyance in Reach 3 that could periodically provide flows to this area in conjunction with concept pulse flows.

Table 4 Pulse flow water volumes to fill reaches

These are the volumes of water required to inundate overbank areas within the project area. Actual water use for ET and uptake are not expected to substantially increase over existing use levels. The majority of this volume will remain in the system and be captured in the Laguna Reservoir downstream.

	Reach 1	Reach 2	Reach 3	Reach 4	Totals
Channel length	15,757	20,591	12,566	10,821	
Cross-sectional Area	280	280	280	280	
Water volume need (cubic feet)	4,411,960	5,765,480	3,518,480	3,029,880	16,725,800
Water volume need per pulse (acre-feet)	101	132	81	70	384.0
Estimated discharges required for annual pulse flows: Every 2 weeks during growing season (6 months); every month during winter months. 18 pulses per year					
Annual Volume (acre-feet)	1,823	2,382	1,454	1,252	6,911

Figure 8 Pulse flows in the Yuma East Wetlands

These photos document a pulse flow in the Yuma East Wetlands in March 2007. The wetted channel is easily identified in the upper photograph with floodplains and terraces on either bank. In the lower photograph, the pulse flow inundates the overbank areas to replenish soil moisture, flush salts, and provide disturbance. (Photos courtesy of Fred Phillips Consulting & Yuma Crossing Heritage Area)

EXCAVATION VOLUMES

An estimation of excavation volumes is difficult due to 1) the lack of an accurate topographic map of the project area and 2) the conceptual nature of the channel cross-section and alignment. However, it is reasonable to assume that the existing ground elevation is relatively close to ground water and despite historic channel scars, relatively level. It is assumed that excavations will be limited to a depth of 7.5 feet. Based on the design cross-section and alignment described earlier in this report, excavation volumes were estimated and presented in Table 5. Actual volumes will vary with more accurate topography and final design.

Table 5 Estimated excavation volumes

	Reach 1	Reach 2	Reach 3	Reach 4	Totals
Channel length (feet)	15,757	20,591	12,566	10,821	
Excavated Cross-sectional Area (sq ft)	660	660	660	660	
Excavation volume (cubic feet)	10,399,620	13,590,060	8,293,560	7,141,860	39,425,100
Excavation volume (cubic yds)	385,171	503,336	307,169	264,513	1,460,189

ESTIMATED PROJECT COSTS

Total project cost depends on many variables not quantified at this conceptual stage. General project tasks include Administration, Analysis/Design, Permitting (Section 404), NEPA compliance, Exotic removal, Excavation, Revegetation, and Maintenance. Maintenance including the treatment of resprouts of exotic species should be anticipated for at least the year following removal. The many variables involved in administration, permitting, and NEPA compliance make estimates of associated costs impractical. Although these costs are not estimated, they can be considerable. Groundwater/soil analysis, design, exotic removal, excavation, and maintenance cost are estimated based on similar experience in the Yuma East Wetlands (Fred Phillips, personal communication) and presented in Table 6.

Table 6 Partial Estimated Costs

Project Administration	Not estimated				
404 permitting	Not estimated				
NEPA compliance	Not estimated				
	Reach 1	Reach 2	Reach 3	Reach 4	Totals
Excavation costs					
Assume $6/cubic yard	$2,311,027	$3,020,013	$1,843,013	$1,587,080	$8,761,133
Salt cedar removal					
Assume $2,500/acre	$487,500	$646,150	$385,975	$292,000	$1,811,625
Analysis/Design/Revegetation/Maintenance					
Assume $7,500/acre	$1,462,500	$1,938,450	$1,157,925	$876,000	$5,434,875
Estimated Cost per habitat acre	$21,851	$21,685	$21,937	$23,588	$22,179
Estimated Total Cost	$4,261,027	$5,604,613	$3,386,913	$2,755,080	$16,007,633

KEY ASSUMPTIONS

The following are key assumptions made in this concept. Many of them will require additional field surveys and other evaluations.

Site Suitability (Soil Texture and Salinity)

For the purposes of this report, the project area within the Laguna District was assumed to be suitable for revegetation with native plant species. No data was identified characterizing soil texture or salinity. The fact that native vegetation is found in the adjacent Old River Channel suggests that soil texture and salinity may not be strongly limiting factors. It should be assumed that soil texture and salinity vary over the broad project area and additional field work is necessary.

Surface Water Delivery System

Surface water for pulse flows could be delivered from the Gila Canal Wasteway with modifications to provide inlet control. This inlet point would allow the largest possible area to be included in the restoration project.

Existing Surface Elevations

Topographic maps of this reach were not available for this report. The landforms are generally flat and scarred with many old river channels suggesting that elevations are not high. However, excavation volumes were not estimated. A detailed topographic map should be created during the design process.

Depth to Groundwater

There is very little groundwater depth data available in this reach. However, the water table is assumed to be relatively close to ground surface (10 feet or less in many areas) given the proximity of the Old River Channel and Mittry Lake.

Groundwater Quality

Given the project areas proximity to the river and distance from agricultural fields groundwater quality is assumed to be relatively low in salinity.

Control of Non-native Vegetation

Dense tamarisk thickets dominate most of the project area and can be problematic to control. For the purposes of this report, the successful strategies utilized under similar conditions in the Yuma East Wetlands Project will be used. These strategies include the mechanical removal of existing vegetation to a depth of 3 feet or greater and the active replanting of all areas with native plant species. Additional maintenance treatments may be necessary for several years.

Ability to Create Self-sustaining Native Plant Communities

As proven in areas such as the Yuma East Wetlands, native plant communities can be established along the Colorado River in historic tamarisk areas. Aggressive planting is required along with enough supplemental water to establish the plants. For the purposes of this project, supplemental irrigation will be provided by carefully timed and managed pulse flows.

POTENTIAL IMPACTS

General Considerations

There are several general considerations regarding this project.

Neither base or pulse flows will be lost from the system. They will be collected at Laguna Reservoir below the project site and can be delivered through the Colorado River to Morelos Dam to meet downstream commitments.

Dense stands of native vegetation have the potential to reduce floodway capacity and lead to localized flooding but the risk is not expected to be greater than under existing conditions.

Fire danger should be reduced with the removal of dense thickets of tamarisk. Native plant communities are not as prone to wildfire as tamarisk.

The project is strategically located between existing infrastructure and valuable habitat. Construction and maintenance of the project should not impact the desilting basin or spoil area, the habitats along the Old River Channel or Mittry Lake, or operation of the newly restored Laguna Reservoir.

Sediment Loads

The potential for increasing sediment loading should be considered in any activity on the LCR. Ground disturbance during the removal of invasive species and excavation of project components would temporarily increase the potential for additional sediments. However, once native vegetation is reestablished this potential is expected to be no greater than under present conditions. Pulse flows will be relatively small, the channel well vegetated, and any resuspended sediments should be captured behind the stop-log structures.

Operation and Maintenance Requirements

Operation and maintenance of this project are expected to be minimal. Once established, the riparian plant communities are expected to be self-sustaining. As discussed earlier, these communities require periodic overbank flows in addition to high groundwater elevations to prosper. Periodic pulse flows are recommended to supply this need. These flows will need to be scheduled and managed. However, the stop-log structures could be set to allow passive management of the flows between reaches once the flows have been introduced.

Resprouting of tamarisk will require attention for several years after construction but the need should decrease as the native riparian community is established. The objective should be to control the dominance of the species rather than remove it entirely.

Sediments may accumulate at the water control structures and require periodic removal. This maintenance can be minimized by providing appropriate machinery access to these points during initial construction.