APPENDIX 3

HABITAT RESTORATION TECHNIQUES COMMONLY USED IN THE MIDDLE RIO GRANDE

Appendix 3 – Habitat Restoration Techniques Commonly Used in the Middle Rio Grande

Method	Geomorphic Response	Habitat Characteristics	Biological Response
Riparian vegetation establishment	Can cause sediment deposition in overbank areas due to increased flow resistance. Sediment deposition in the overbank can increase main channel sediment transport capacity by raising the bank height.	Directly adds to the amount of riparian vegetation.	Increased growth of riparian vegetation in overbank areas can enhance habitat conditions for both the flycatcher and the silvery minnow. Encroachment of mature vegetation may eventually lead to a narrower and more confined channe,l which is negative for silvery minnow habitat.
Longitudinal bank and bar/island lowering	Lowered bank line can promote a wider channel width and decreases in main channel velocity, depth, shear stress, and sediment transport capacity reduces potential for channel degradation, thereby maintaining a higher water table and more connectivity with backwaters and side channels. Increases overbank flooding, creating variable depth and velocity habitat. During subsequent years, sediment may deposit in the lowered bank line area occupied by vegetation, which may reduce overbank conveyance capacity.	Promotes overbank flooding favorable for establishment of riparian vegetation as well as creating variable depth and velocity habitat. Reduces potential for channel degradation, thereby maintaining a higher water table and more connectivity with backwaters and side channels.	Increased overbank flooding creates variable depth and velocity habitat types including silvery minnow nursery habitat during spring runoff. Increased overbank flooding maintains moist soil conditions during flycatcher territory establishment. Growth of native riparian vegetation can enhance habitat conditions for the flycatcher.
Bankline embayments (willow swales and backwater areas)	Historical channel slow water velocity and shallow depth bank line habitat is restored/rehabilitated. Bank line embayments are zones of sediment deposition and have a finite lifespan without periodic re-excavation.	Slow water velocity and shallow depth bank line habitat.	Increase in egg retention and availability of nursery larval habitat during high flow. Increases probability of native vegetation growth and potential for flycatcher habitat.
large woody debris (LWD)/ perennial pools	Creates pools, generates scour and substrate sorting, and increases depth and velocity complexity. Can promote side channel formation and maintenance. LWD in the Middle Rio Grande can lead to sediment deposition, including formation of islands, in reaches with large sand loads. Prone to sedimentation after inundation. Short life span for LWD using cottonwood trees on Middle Rio Grande.	Adds complexity to the system. Sediment deposition can create areas where new riparian vegetation becomes established. Can create variable depth and velocity habitat. Can provide structure and habitat for fish.	May provide for habitat diversity in areas with monotypic flow patterns and refugia habitat during low flows. These habitats may also provide refuge for predatory fishes. Increased areas of moist or flooded soil conditions could assist in flycatcher territory establishment and native vegetation recruitment.

Exotic vegetation removal	Exotic vegetation removal may result in channel widening and increased flood plain connectivity. Channel widening could reduce channel flow depth and velocity. Degree of change is dependent on degree of connection between the main channel and the surface upon which the exotic vegetation is being removed. In removal areas that are currently disconnected from the river, there is a negligible effect on the fluvial geomorphology of the river channel. The degree of influence exotic vegetation removal has on the geomorphology is also influenced by the timing of peak flows in relation to the period when exotic vegetation removal occurred. May also have an influence on the geomorphology of disconnected, historical flood plain areas as the removal of trees may allow for a higher groundwater table.	Could result in channel widening, increased flood plain connectivity, allow for a higher groundwater table and increase chances of native vegetation outcompeting exotics.	Dependant on site-specific details, the removal of exotic vegetation could temporarily remove flycatcher habitat as species such as saltcedar do provide the structural composition required for nesting. Over the long term, if replaced with native vegetation and a wider channel and increased flood plain connectivity, could re-establish better nesting habitat over time. The temporary removal of vegetation may allow for a more active channel with connectivity to the flood plain creating silvery minnow habitat.
Island and bank destabilization	Promotes a wider channel with greater flood plain connectivity and balances sediment. Reduces further degradation of the channel and lowering of the local water table. Sediments from destabilized areas may deposit new bars suitable for vegetation growth. Can locally increase sediment supply for a temporary period of time if erosion occurs. New sediment balance may be temporary unless incoming loads also increase. Can provide increased flood carrying capacity. Cleared and lowered bankline or island areas can become zones of sediment deposition and may need to be re-cleared and re-excavated for benefits to continue. Degree of change is dependent on degree of connection between the main channel and flood plain and the timing of peak flows in relation to the period when destabilization occurred	Reduces further degradation of the channel and lowering of the water table. Sediments from destabilized areas may deposit new bars suitable for vegetation. Clearing and destabilization would result in the temporary loss of this habitat. Islands/bars that are more connected to the main channel can provide RGSM with a greater variety of depth and velocity habitat types.	Provides low velocity habitat during high flows for adult fish. Increased overbank flooding creates variable depth and velocity habitat types including silvery minnow nursery habitat during spring runoff and aids in increasing egg and larval entrainment. Loss of habitat may be temporarily negative depending on site-specific details and proximity to flycatcher territories; however, sediment accumulation forming new bars or islands could promote new seed source establishment and potentially young native successional stands to develop into flycatcher habitat. By reducing further degradation of the channel and lowering of the water table, the flood plain has a better chance of connectivity, which is better overall for the flycatcher.

Side channel (high flow and oxbow reconnection)	Important to natural systems for passage of peak flows. Maintains higher water surface elevation and ground water table. Can reconnect the flood plain to the channel. Sediment tends to fill in high flow side channels over time. Can decrease peak flow water surface elevation and may decrease sediment transport capacity until sediment blocks the side channel. Method provides for reduced main channel sediment transport capacity. Sediment tends to deposit at the inlets and outlets. Periodic inlets and outlets sediment removal may be needed to maintain project benefits.	Side channels result in raising the ground water table and surface flows to developing riparian areas. Maintains higher water surface elevation and ground water table, adding to the health of the riparian zone. Can reconnect the flood plain to the channel, creating nursery habitat for the Rio Grande shiny minnow (RGSM) with variable depth and velocity habitats.	Provides low velocity habitat during high flows for adult fish and developing larvae. Increase in retention of eggs and larvae during high flows. Raising the ground water table to provide water to developing riparian areas increases vegetation health. Periods of increased surface flows, particularly during mid-May to mid-June, increases probability of flycatcher territory establishment in areas with suitable habitat.
GRF/sill	Grade controls can reduce the gradient upstream by controlling the bed elevation and dissipating energy in discrete steps. At least during low flows, the upstream water surface is raised, depending on structure height above bed. Upstream velocity is reduced. For low head structures (1 to 2 feet), the amount of upstream sediment storage is low and usually does not cause downstream bed level lowering as a result of upstream sediment storage. In sediment supply-limited reaches, channel degradation downstream of the structure will continue as a result of excessive sediment transport capacity. For gradient restoration facilities (GRF), the bed is fixed; for a rock sill, the rock launches into the downstream scour hole.	Reduces channel degradation upstream of this feature and can promote overbank flooding and raise the water table. This provides more opportunity for riparian zone establishment and development. Backwater areas could develop upstream, which would raise the water table. If downstream degradation continued, then the water table would be lowered, reducing water availability to the riparian forest.	Increased overbank flooding upstream creates variable depth and velocity habitat types including potential spring runoff silvery minnow nursery habitat. Steeper apron slopes may restrict fish movement, while lower slopes can meet flow velocity requirements for fish passage. A reduction in channel degradation and increase in overbank flooding and water table levels would likely increase vegetative health and could attract flycatchers, particularly if overbank flooding conditions occurred during territory establishment. However, the opposite effect likely would occur downstream.

Bendway weirs	The location of the thalweg is shifted away from the outer bank line. Local scour at the tip occurs because of the three-dimensional flow patterns. Secondary currents are interrupted, and flows are redirected away from the bank. The outer bank can become a zone of lower velocity. The combined effect of the tip scour and lower velocity along the bank line creates a flow condition of variable depth and velocity. Scalloping also can occur along the bank line, or sediment deposition between structures depending upon local conditions and bendway weir geometry. Can reduce local sediment supplied from bank erosion, because the current river alignment is maintained.	Sediment deposition between structures may allow establishment of riparian vegetation and backwater areas. Channel deepening and tip scour could locally lower the riverbed and lower the ground water table.	Depending on site-specific details, bendway weirs would allow for overbank flooding conditions for flycatchers. However, depending on the location and the degree of lowering the ground water table, construction efforts could impact flycatcher suitable habitat. Silvery minnows could be stranded in pools that would form between weirs as flow receeded. However, it could provide habitat diversity and deep habitat during low flow conditions.
Rootwads	Creates local scour pools and variable depth and velocity habitat Increases flow resistance along the bank line, which dissipates energy, traps and retains sediments, and creates turbulence that can move the main current away from the bank line. Cottonwood tree rootwads have a design span of about 5 years; therefore, this method has been used with many other methods to create habitat.	Adds complexity to the system. Variable depth and velocity conditions can be created. Some potential for creating areas of sediment deposition (depending on specific placement), which is generally beneficial to the establishment and development of riparian vegetation.	Can provide structure and habitat for silvery minnow. Isolated pools are often maintained in scour pools caused by debris, including rootwads. This can serve as refugia habitat for silvery minnow during low flow periods. Similar to LWD. Could trap sediment and encourage new native vegetative growth.
Jetty removal	Jetty removal may result in channel widening and increased flood plain connectivity. However, vegetation often promotes more bank stability than jetties, thus removal may not result in channel widening and increased flood plain connectivity. Channel widening could reduce channel flow depth and velocity.	The habitat may not change if the existing vegetation has more effect on bank stability than the jetties themselves. Otherwise, channel widening could reduce channel flow depth and velocity and create more bank line habitat.	If banks are destabilized, there can be an increased availability of shallower and lower velocity habitat for the silvery minnow. By destabilizing the bank, could encourage lateral migration of the river providing more opportunity for successional age classes of potentially native vegetation for flycatcher habitat.

Removal of lateral constraints	Can encourage current geomorphic processes to continue, such as lateral migration, and the creation of new flood plain and riparian areas. This may increase opportunities for the river to connect with historical channels and oxbows. For incised channels, may provide an opportunity to establish new inset flood plain and riparian zone. Lateral river movement creates broader flood plain. Lateral bank movement should result in deposition of sediment downstream. The river may establish bars and low surfaces as lateral migration continues to occur. Longer meander bends may establish greater pool depth and eroding banks providing additional complexity.	Lateral river movement creates broader flood plain and more favorable riparian zone habitat. Lateral bank movement should result in deposition of sediment downstream. The river will establish bars and low surfaces, where vegetation can become established. Longer meander bends may establish greater pool depth and eroding banks with vegetation falling into the channel, providing fish cover and habitat complexity.	Inset flood plain and riparian zones increase overbank flooding and create variable depth and velocity habitat types including potential spring runoff for silvery minnow nursery habitat. The lateral migration of the river provides more opportunity for successional age classes of potentially native vegetation for flycatcher habitat.
Longitudinal stone toe with bioengineering	Studies about longer reach response are contradictory. Maintains the local current river alignment, and the point bar remains static. The flow velocity and depth are greater than typically found in natural channels along the outside bank of a river bend. Can be susceptible to flanking if upstream channel migration occurs. Eliminates sediment supplied from bank erosion. Bank line vegetation is established.	Prevents lateral migration and the establishment of new depositional zones where vegetation could become established. Eliminates sediment supplied from bank erosion. The steep bank angle on the outside of the bend limits fish cover, except for the riprap interstitial spaces. The point bar remains connected to the main channel and remains static. The flow velocity and depth are greater than typically found in natural channels along the outside bank of a river bend. Bioengineering provides very minimal benefits to riparian community.	