Recovery Implementation Strategy

Neosho Mucket (*Lampsilis rafinesqueana*)

Courtesy of Dr. Chris Barnhart (Missouri State University)

Prepared by:
The Neosho Mucket Recovery Team

This Recovery Implementation Strategy describes the activities to implement the recovery actions identified in the Final Recovery Plan for the Neosho Mucket (*Lampsilis rafinesqueana*) (Service 2018). The strategy provides a narrative and the implementation schedule for the Neosho Mucket recovery activities. The implementation schedule estimates the cost for implementing recovery activities for removal from the *List of Endangered and Threatened Wildlife* (delisting). Additionally, the strategy document restates the criteria for determining when the Neosho Mucket should be considered for delisting. A Species Biological Report, which provides information on the species' biology and status and a brief discussion of factors limiting its populations, is available at http://www.fws.gov/arkansas-es. The Recovery Implementation Strategy and Species Biological Report are finalized separately from the Recovery Plan and will be updated on a routine basis.

Recovery Strategy

The primary strategy for recovery of Neosho Mucket is to conserve the range of genetic and morphological diversity of the species across its historical range; fully quantify population demographics and status within each river; improve population size and viability within each river; reduce threats adversely affecting the species within each river (*e.g.*, habitat degradation from sedimentation, chemical contaminants, channel destabilization, water diversion); emphasize voluntary soil and water stewardship practices by citizens living and working within each watershed; and to prevent local extirpation where recruitment failure is occurring and for reintroduction within rivers historically occupied by Neosho Mucket. Neosho Mucket recovery will require an increased understanding of the species status throughout its range; developing information on life history, ecology, mortality, and habitat requirements; improving our understanding of some poorly understood threats potentially affecting the species; and using this information to implement management actions to promote recovery. This recovery strategy increases the species representation, resiliency and redundancy to ensure populations persist over time in the wild.

Conservation and recovery of the species will require human intervention for the immediate future. Human activities, population numbers, and associated adverse effects will change within watersheds, particularly those associated with urban sprawl and energy development. Therefore, it is essential to characterize and monitor aquatic habitats on a watershed scale, and rapidly respond to changing conditions, whether through negotiation and partnerships to alleviate threats, or through husbandry and augmentation and/or reintroduction of individuals in appropriate areas. This approach will require monitoring extant populations and characterizing current habitat conditions in each river.

Recovery Goal

The goal of this Neosho Mucket Recovery Plan is to stop the decline and enhance Neosho Mucket populations to prevent extinction and support delisting from the *List of Endangered and Threatened Wildlife*. To achieve this goal it will be necessary to establish naturally self-sustaining populations with healthy long-term demographic traits and trends. We are defining reasonable delisting criteria with the best available information on this species. Criteria will be reevaluated as new information becomes available.

Recovery Criteria (delisting):

(1) Two of four targeted river basins (Illinois, Verdigris, Neosho, and Spring River basins) contain viable populations[1] with positive or stable basin-wide population trend as evidenced by a population number measured with sufficient precision to detect change of ±25 percent (Factors A, D, and E).

(2) Spatial distribution of natural or stocked aggregations distributed throughout the basin is sufficient to protect against local catastrophic or stochastic events (Factors A and E).

(3) All life stages are supported by sufficient habitat quantity and quality (see Primary Constituent Elements in *Species Biological Report for Neosho Mucket*) and appropriate presence and abundance of fish hosts necessary for recruitment (Factors A, D, and E).

(4) Threats and causes of decline have been reduced or eliminated (Factors A, D, and E).

Recovery Actions Narrative with Stepped-down Activities

1.0. Establish viable populations within two of four targeted river basins (Illinois, Verdigris, Neosho, and Spring River basins) Illinois, Spring, Verdigris, and Neosho river basins (addresses Factors A and E). Population declines need to be arrested and reversed to establish viable populations in each river basin. Numerous barriers exist in each river basin that prevents the natural dispersal and recolonization of populations and exchange of genetic material. Following improvements to habitat and water quality, it is likely that some subpopulations will need augmentation and reintroduction to increase distribution, abundance, and genetic diversity of Neosho Mucket. Conservation and recovery of Neosho Mucket ultimately rely on our ability to increase and expand extant populations such that they have the ability to persist following natural events and localized anthropogenic effects.

1.1. Assess population viability. Estimating the likelihood of population extinctions will help (1) define the urgency of needed recovery efforts in each river basin, (2) identify critical information gaps and key areas to focus recovery efforts, (3) facilitate the comparison of different management options, and (4) assess the effects of habitat loss. Critical population size below which stochastic effects become important is unknown. Ultimately this recovery task will assess whether a population is self-sustaining (*i.e.*, viable) over the long-term and determine how many individuals are needed to safeguard against genetic effects (e.g., inbreeding depression) and effects of natural fluctuations in environmental conditions and survival.

[1] A viable population is defined as a wild, naturally reproducing population that is able to persist and maintain sufficient genetic variation to evolve and respond to natural changes and stochastic events without further human intervention. Viable populations are expected to be large and genetically diverse, include at least five age classes with at least one cohort ≤ 7 years of age, and recruit at sufficient rates to maintain or increase population size.

1.2. Propagate Neosho Mucket (head start young or infest host fish for release) to augment declining, wild populations or to restore extirpated populations. This program will review and apply all information generated by genetic studies described in Recovery Task 3.2 below. It will determine the location of source populations and appropriate numbers of brood stock. This recovery task will support opportunities for reintroduction and augmentation. Propagation techniques also may be utilized to produce excess individuals for research studies (*e.g.*, contaminant studies).

1.2.1 Identify stream sites for reintroduction and augmentation. The recovery criteria require reestablishment of Neosho Mucket in portions of its former range. Mussels have low dispersal capability and small decreases in dispersal may increase the probability of extirpation. This recovery task will be necessary to establish additional populations and may be required to secure existing populations. It should be accompanied by careful evaluation of existing habitat and only after vigorous habitat protection and restoration efforts and may require studies to assess the suitability of sites considered for reintroduction and augmentation.

1.2.2 Genetic stock is representative of genetic diversity across range. Results generated by Recovery Task 3.2 below will dictate genetic considerations for augmentation and reintroduction efforts.

1.2.3 Provide individuals for research. Periodically, there may be research needs that necessitate the use of Neosho Mucket rather than a surrogate species. Propagation techniques are well developed for Neosho Mucket and production of surplus animals periodically for research is not expected to hinder or delay other recovery activities.

1.2.4 Assess success of augmentation and reintroduction efforts. Service policy requires a Propagation, Augmentation, and Reintroduction Plan prior to initiating these activities for threatened and endangered animals. A cooperative interagency *Plan for Controlled Propagation, Augmentation, and Reintroduction for Neosho Mucket (Lampsilis rafinesqueana)* (Service 2014) satisfies this requirement. Evaluate the success or failure of previous efforts prior to prioritizing propagation, augmentation, reintroduction as a recovery strategy, as controlled propagation should not be a long-term substitute for addressing factors that caused the species decline and for ameliorating or managing those factors (McMurray and Roe 2017, Patterson *et al.* (2018).

1.2.5 Translocate Neosho Mucket as necessary to maintain genetic diversity, increase fertilization rates (low population density), and avoid mass die-offs associated with stochastic or anthropogenic-induced events. Adult and juvenile Neosho Mucket may require translocation periodically to enhance recovery efforts and salvage animals

from stochastic events (*e.g.*, drought) or areas experiencing habitat loss. Information generated from Recovery Task 3.2 and the propagation, augmentation, and reintroduction plan will determine location and stocking density at translocation sites.

2.0 Develop and implement a monitoring protocol for the Neosho Mucket (addresses Factors A and E). To assess the efficacy of conservation measures, population surveys in occupied and formerly occupied stream reaches should be performed using repeatable (qualitative and quantitative) methods and similar sampling frequencies. Occupancy modeling may be a viable cost effective method. Changes in distribution and abundance (losses or gains), habitat quality, etc. should be considered in focusing recovery efforts and adjusting priorities as necessary. Land use changes affecting habitat should be analyzed through field observation or remote sensing technology at five-year intervals in river basins with rapid urban sprawl and at 10-year intervals in watersheds dominated by agriculture and forestry. Habitat characterization and monitoring also will be necessary to determine whether threats have been alleviated and to provide reasonable assurance that populations will be protected from foreseeable threats

3.0. Identify, prioritize and conduct research to enhance the conservation and recovery of Neosho Mucket (addresses Factors A and D). General aspects of the biology and ecology of the Neosho Mucket (*e.g.*, principal host fishes, culture techniques, age at maturity, and sensitivity to certain contaminants) are known, but data gaps important to conservation still persist. This recovery task will provide insight into threats and associated stressors, vulnerabilities in the life cycle, and inform future management decisions.

3.1. Determine life span, growth rate, abundance and availability of host fish, recruitment, and other unknown variables that interact to determine demographic structure and growth rates of populations. Factors controlling the population dynamics of this species are largely unknown. However, fish host abundance and availability clearly affect recruitment and population size (Haag 2012). Historically, few Neosho Mucket populations existed in isolation. Factors such as landscape connectivity and immigration are likely important in determining population growth and persistence, and transcend localized processes. The species' known fish hosts (black bass) are highly mobile, but this mobility does not necessarily ensure persistent fish host populations. Stream flow also affects recruitment patterns suggesting hydrologic alteration may disrupt normal recruitment patterns (Peterson *et al*. 2011). This recovery task will determine life history traits and other factors that influence population viability. One potentially useful study would include surveys of fish communities at sites showing good Neosho Mucket recruitment compared to sites with no Neosho Mucket recruitment.

3.2. Determine genetic variation within and among populations. Knowing the genetic structure and diversity of Neosho Mucket will inform future conservation recovery tasks. Populations are isolated from one another by several dams. This

recovery task will analyze the genetic structure and diversity of extant populations. It will provide information on population heterozygosity, observed number of alleles, and effective population size for each river basin. In turn, this information will be used to identify (1) populations suffering from low genetic diversity and (2) potential "seed" populations suitable for propagation activities. This recovery task also will determine whether genetic variation is being lost due to processes of genetic drift or inbreeding and whether propagation efforts are successful at maintaining representative genetic diversity in augmented populations.

3.3. Contaminant sensitivity to all life stages. Information on life stage sensitivity to contaminants is poorly known. This recovery task will determine acute and chronic toxicity threshold for several pollutants of concern which is information essential to the management and protection of this species. This task will involve water and sediment quality surveys and will substantiate or eliminate suspected causes of population declines. New information will be shared among partners and immediately applied.

3.4. Determine sediment deposition rates v. survivorship of Neosho Mucket. Excessive sedimentation and its associated effects are not good for mussels or free-flowing streams. Many mussel declines have been attributed to sedimentation from a variety of land use activities despite an almost complete lack of direct evidence (Haag 2012). Understanding why nearly all mussel species have exhibited population declines when some species are silt tolerant (and in some cases silt dependent) is important to understanding the stressors limiting population growth. This recovery task will provide information on particle size, rate of deposition, timing of deposition events, and how bed load dynamics influence survival.

3.5. Determine habitat requirements and limitations for all life stages. The systematic and rapid destruction of riverine habitats by dams is perhaps the single most important factor in the decline of Neosho Mucket. Systematic destruction of habitat in the mid Arkansas River basin by dams has exacerbated other known stressors and hindered or precluded the reestablishment of mussel populations in affected stream reaches. This recovery task will assess habitat limitations, particularly those associated with dam operations, and provide recommendations to alleviate or minimize stressors limiting survival and recruitment.

3.6. Determine interaction between fish host visualizing Neosho Mucket lure and effects on reproduction (*i.e.*, water clarity effects). Dependence on a fish host for reproduction is considered a necessity for mussels (Neves 1993). This recovery task will provide information on the ability of a host fish to visualize a mussel lure during varying levels of water clarity (Hartfield and Hartfield 1996).

3.7. Investigate secondary host use by Neosho Mucket and the significance of conglutinate release in utilization of hosts. Largemouth and smallmouth bass

are effective hosts of Neosho Mucket, but only 10 other potential host species have been tested (Barnhart and Roberts 1997). Further host study is advisable, particularly because the short-term, summer brooding period of Neosho Mucket is peculiar among *Lampsilis* species (Shiver 2001). Most other mussel species with similar brooding habits rely on conglutinates to infect host fish (Barnhart *et al.* 2008).

3.8. Determine recreational effects to Neosho Mucket and its habitat in the Illinois and Elk Rivers. Canoeing is a popular recreational activity on the Illinois and Elk Rivers which are in close proximity to major urban areas in northwest Arkansas, northeast Oklahoma, and southwest Missouri. Mussels may be dislodged from the substrate and subsequently displaced to unsuitable habitats or crushed when canoes drag bottom. This recovery task will determine sites that may be susceptible to effects associated with recreational activity and actions that can be implemented to minimize disturbance.

3.9. Determine correlations between presence/absence and land use and other potential causal effects. Increases in impervious surface and clearing of riparian habitat has been implicated in changes to stream hydrology and geomorphology in the Illinois River with little to no empirical data. Similarly, other land uses such as agriculture and urban development have been implicated as threats owing to attendant sedimentation. Empirical data clearly associates mussel declines with metal mining and ore processing activities in the Tri-State Mining Area. This recovery task will determine correlations between land use changes and mussel distribution and abundance. It will help direct conservation activities towards those measures with the best return on investment (*i.e.*, conservation measures with the most potential to alleviate/minimize stressors).

4.0. Watershed and habitat improvement and protection (addresses Factors A, D and E). Protection, enhancement, and restoration of critical habitats is vital to Neosho Mucket conservation and recovery. Habitat protection through broad, watershed scale initiatives will be a primary focus of conservation efforts. Successful species and habitat management and recovery will require public involvement, monitoring, and commitment of resources. Where adopted, best management practices (BMPs) can be effective in preventing or reducing nonpoint source pollution. For example, many agricultural BMPs are designed to reduce levels of silt, animal wastes, fertilizers, and pesticides in storm water runoff (Benthrup 2008). Silviculture BMPs minimize the release of sediments, nutrients, organics and other chemicals and protect stream canopies. The BMPs are developed by state and industry planning partnerships with public participation, and can be effective when they are properly implemented and adequately maintained. However, BMPs are not always properly implemented or maintained. Industry groups, organizations, and state resource agencies should continue to promote and improve BMPs as a non-regulatory approach to aquatic habitat management. This recovery task seeks to eliminate or minimize threats to habitat quality and integrity.

4.1. **Restore tail water river reaches**. Physical habitat may be intact downstream of some dams. However, water released downstream of dams may result in chronic cold or hot water temperature, low dissolved oxygen concentration and altered flow regimes. Opportunities for tail water restoration are more probable than dam removal and have been successful in restoring mussel communities in the Green, Tennessee and Mobile River basins. This recovery task will identify opportunities for tail water restoration and will establish plans that when implemented will restore more natural flows and improve water quality.

4.2. **Promote and coordinate with existing and future restoration actions in Tri-State Mining area affected waters (e.g., NRDA efforts).** Tri-state mining produced 50 percent of zinc and 10 percent of lead in the United States from 1850 – 1950. Mining in the area left the environment contaminated with heavy metals such as lead, zinc, and cadmium. Cleanup and reclamation of mined areas is the responsibility of state, federal, and local entities. This recovery task seeks to improve water and sediment quality in the Spring River basin.

4.3. **Promote ecologically sustainable "green" development and "green spaces" along stream corridors (*i.e.*, riparian areas and bank stabilization) in areas experiencing rapid urbanization (hardened permeable surfaces, laminar flow discharge rather than concentrated flows, storm water retention, stream corridor buffers, other environmentally sensitive construction designs.** Destruction of natural habitats and contamination of surface and ground waters are environmental effects associated with urban development (Lopez 2014). Northwest Arkansas was ranked the 15th fastest growing region in the United States in 2012. Water pollution, which adversely affects drinking water, the rural environment, and activities such as fishing, recreation and tourism may limit future economic development. Solutions for the continued use of water resources will require changes within the water industry and by a wide range of organizations and individuals. This recovery task pursues a regional strategy for ecologically sustainable development while balancing ecological, social, and economic demands for water and safeguards the welfare of future generations and the environment. It also will establish objectives and guiding principles that enhance individual and community well-being.

4.4. **Promote and support a watershed management approach to water quality and quantity.** A watershed management approach synchronizes water quality and quantity monitoring, inspections, and permitting within a defined watershed. It has the potential of integrating imperiled species habitat concerns with all other water quality and quantity issues, including economic and human health, within the defined watershed. This approach allows a greater degree of public awareness about, and involvement with, local water quality and quantity issues and decisions. A regional strategy developed as part of Recovery Task 4.3 will support this action. Community outreach and feedback will be essential to gaining support for this recovery task.

4.5. Develop coordinated plan to address wastewater treatment plant effluents for domestic and industrial wastes. This recovery task seeks to return wastewater to the environment in a way that communities accept after considering both environmental and cost factors. This recovery task will seek to avoid risks to human health, maximize reuse of effluent (for the value of water and nutrients), minimize adverse effects to land and surface and ground waters when used in land applications, consider alternative disinfectant techniques, and maintain water quality objectives for receiving waters when discharging to surface waters. Effluent water quality should be protective of all life stages of Neosho Mucket, and modified as necessary to support emerging science. Effective monitoring and adherence to state and federal permit conditions will be essential to implementing a successful plan.

4.6. Promote proper implementation and maintenance of BMPs for reducing sediment loads associated with construction activities. Sediment contributions from construction sites without BMPs are approximately 100 and 1,000 times greater than pasture and forest land uses, respectively (ADEQ 2004). The proper suite of erosion control BMPs coupled with proper implementation and maintenance can reduce sediment loads from storm water by as much as 95 percent. This recovery task will promote the expanded application of appropriate BMPs through coordination and awareness with state and federal regulatory agencies and developers and construction contractors. It also will seek to gain local community support through ordinances requiring specific BMP adoption, placement, and maintenance.

4.7. Develop and implement standards for water withdrawal and water conservation. See Recovery Tasks 4.3 and 4.4. In addition, minimum stream flow requirements for mussels are poorly known. With increasing demands being placed upon surface and ground water supplies, this recovery task will attempt to identify appropriate flow standards to support native mussel populations, encourage consideration of alternative technology, and reduce future conflicts.

4.8. Remove non-functional dams (e.g., Lake Francis, low head). Many dams continue to provide benefits of hydroelectric power, flood control, water storage, navigation, and recreation and removal is clearly unrealistic. Removal of non-functional dams has accelerated in recent years. Benefits to mussels are generally tangential to primary goals of dam removal. Reservoirs behind dams may act as sinks for sediment, nutrients, and other contaminants. Due to the potential deleterious effects associated with some dam removals, this recovery task should be used with caution until methods to minimize potential negative effects are better understood.

4.9. Implement adequate industrial, highway, and rail safeguards to minimize potential for catastrophic die-offs. Some areas within the historical range of the Neosho Mucket are experiencing rapid urbanization. Transportation corridors are increasingly dissecting streams, thereby increasing the potential for catastrophic

spills. This recovery task will develop spill response plans to minimize contaminant exposure.

4.10. Work with state and private partners to promote land and water stewardship awareness within the range of Neosho Mucket. Local offices of state and Federal agencies and private organizations (*e.g.*, Water Conservation Districts, Natural Resources Conservation Service, State Forestry Commission, private industry groups, environmental groups, etc.) can inform local landowners of species presence, conservation needs, special management concerns and appropriate BMPs for alleviating these concerns. This recovery task seeks to provide landowners with innovative solutions or assurances and to garner support for stewardship activities. In some watersheds, standard BMPs may need to be adjusted according to stream size, soil conditions, and land use intensity and practices. Various state and federal programs are available to help offset costs associated with implementing BMPs on private land.

4.11. Encourage the maintenance and restoration of adequate streamside management zones (SMZs) within the range of Neosho Mucket. Properly designed SMZs, acting as filter strips, can buffer the effects of sediment and chemical contaminants on water and habitat quality. The SMZs are widely recognized as a cost effective habitat management practice. For example, the American Forest and Paper Association's Sustainable Forestry Initiative requires its members to meet or exceed existing SMZ state standards. The SMZs are also effective in controlling urban and suburban storm water runoff.

4.12. Develop and implement tribal programs to promote watershed stewardship on tribal lands. See Recovery Tasks 4.10 and 4.11.

5.0. Enhance the level of protection through policy, regulation, and enforcement (addresses Factors A and D). Regulatory agencies, municipalities, industry, and private landowners should thoroughly consider and apply alternatives to habitat modification, waste disposal, and other activities adversely affecting streams.

5.1. Minimize instream effects from activities conducted or permitted by regulatory authorities. Regulated industries, sewage treatment plants, and storm water discharges should be monitored at a frequency sufficient to ensure compliance with water quality standards. Unpermitted discharges should be identified and brought into compliance. State and Federal regulatory programs should ensure consistent compliance with permit conditions and discharge limitations. Mussel life history requirements and sensitivity to pollutants should be considered when establishing permit limits and conditions.

5.2. Work with states under the Triennial Review Process to ensure water quality standards provide for mussel survival and recovery. The States, under the auspices of the Environmental Protection Agency (EPA) and Clean Water Act (CWA), have established numeric and narrative criteria for numerous

contaminants. Where current numeric criteria are found not to be protective of the various life stages of mussels, these criteria should be revised. The EPA and Service should request that States revise these numeric criteria during the next triennial review. Further, the EPA should be requested to make a CWA section 303(c)(4)(D) finding that the criteria are not adequate if the State does not make the necessary revision. The sensitivity of various life stages of mussels will be determined under Recovery Task 3.3.

5.3. Encourage proactive conservation under section 7(a)(1) of the Endangered Species Act. Section 7(a)(1) implementation is discretionary. However, it authorizes all Federal agencies to use their authority to conserve threatened and endangered species. Developing 7(a)(1) conservation plans with Federal agencies embraces a program-wide approach, has high adaptive potential, maintains flexibility, is cooperative, and has a recovery objective. This recovery tasks promotes Neosho Mucket conservation and recovery through implementation of section 7(a)(1).

5.4. Develop recommendations to address regulatory deficiencies. During implementation of this recovery plan, it is critical to Neosho Mucket survival that Federal and State agencies continue to protect extant populations with those laws and regulations that address protection and conservation of the species and their habitats. This recovery task seeks to continue using existing legislation and regulations to conserve and recover Neosho Mucket while identifying and quantifying inadequacies in water quality classifications, waste load allocations, permit review processes and other important water quality actions.

5.5. Encourage cities to adopt (codify) BMPs in their city construction ordinances. The Karst Initiative in northwest Arkansas is starting to show success with certain communities adopting (codifying) BMPs to protect water quality. Widespread adoption of BMPs by communities is essential to ensuring proper implementation, maintenance and compliance. Benefits (social, economic, and environmental) associated with adopting BMPs into city ordinances needs to be conveyed to the public and administrators. This recovery task seeks to develop a standardized suite of BMPs for development and construction activities, gain public support for such initiatives, and work with local municipalities to adopt ordinances to improve water quality. This recovery criterion is particularly important in large metropolitan areas or areas experiencing rapid urbanization.

6.0. Develop and implement strategies to prevent the spread of competitive, nonindigenous (nonnative) species (addresses Factor E). Zebra mussels continue to spread to new reservoirs and streams within the Neosho Mucket range. The threat from zebra mussels is expected to be minimal in streams where Neosho Mucket occurs if zebra mussel abundance remains low. Since zebra mussel populations are typically maintained in streams with barge navigation and introduced to new streams and reservoirs via transport on watercraft from infected to uninfected waters, this recovery criterion seeks to prevent the spread of zebra mussels and other competitive, nonnative species by public outreach and requirements for

decontaminating watercraft.

7.0. Periodically review recovery progress and strategy. The species will be monitored under Recovery Task 2.0. Recovery efforts and priorities may need to be adjusted as further information is acquired.

Summary of threats, criteria, actions, and activities

Listing Factor	Threat	Criteria to Delist	Action	Activity
A	Habitat modification and curtailment	All	1, 2, 3, 4, 5, 6, 7	1.1, 1.2.1-1.2.5, 2.0, 3.1-3.8, 4.1-4.12, 5.1-5.5, 6.0, 7.0
D	Inadequacy of existing regulatory mechanisms	All	3, 4, 5	3.3, 4.5, 4.7, 4.10-4.11, 5.1-5.5
E	Population fragmentation and isolation, invasive species, temperature, climate change	All	1, 2, 4, 6	1.1, 1.2.1-1.2.5, 2.0, 4.1, 4.4-4.8, 4.10-4.12, 6.0

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RECOVERY IMPLEMENTATION SCHEDULE

Recovery schedules are intended to assist the Service and other stakeholders in planning and implementing actions and activities to recover and/or protect endangered and threatened species. The following Implementation Schedule indicates activity numbers, activity descriptions, activity duration, potential stakeholders and responsible agencies, and estimated costs. It is a guide for planning and meeting the objectives discussed in this strategy. The Implementation Schedule outlines recovery activities, their estimated costs for the first 30 years of this recovery program, and the total cost to the goal of delisting. **Actual expenditures by agencies and other partners is contingent upon appropriations and other budgetary constraints.**

While the ESA assigns a strong leadership role to the Service for the recovery of listed species, it also recognizes the importance of other Federal agencies, States, and other stakeholders in the recovery process. The "Responsible Agency" column of the Implementation Schedule identifies partners who can make significant contributions to specific recovery tasks. The identification of agencies and other stakeholders within the Implementation Schedule does not constitute any additional legal responsibilities beyond existing authorities (e.g., ESA, CWA, etc.).

Key to acronyms used in the Implementation Schedule

ADEQ – Arkansas Department of Environmental Quality
AGFC – Arkansas Game and Fish Commission
EPA – U.S. Environmental Protection Agency
FHWA – Federal Highway Administration
FWS – U.S. Fish and Wildlife Service
KDWPT – Kansas Department of Wildlife, Parks, and Tourism
MDC – Missouri Department of Conservation
ODWC – Oklahoma Department of Wildlife Conservation
USACE – U.S. Army Corp of Engineers

NEOSHO MUCKET IMPLEMENTATION SCHEDULE				COST ESTIMATES ($)							Comments
Activity #	**Activity Description**	**Activity Duration**	**Responsible Parties**	**Year 1 – 5**	**Year 6 – 10**	**Year 11 - 15**	**Year 16 - 20**	**Year 21 - 25**	**Year 26 - 30**	**Total Recovery Costs**	
1.1	Assess population viability	3 years	FWS, AGFC, MDC, KDWPT, ODWC		150K		150K		150K	450K	
1.2	Propagate Neosho Mucket (head start young or infest host fish for release) to augment declining, wild populations or to restore extirpated populations.	20 years (as necessary)	FWS, AGFC, MDC, KDWPT, ODWC, PTIO, Academia, Zoos	250K	250K	250K	250K			1M	
1.21	Identify stream sites for reintroduction and augmentation.	As necessary	FWS, AGFC, MDC, KDWPT, ODWC, PTIO		5K					5K	
1.22	Genetic stock is representative of genetic diversity across range.	20 years	FWS, AGFC, MDC, KDWPT, ODWC, Academia							See Activity 3.2	
1.23	Provide individuals for research	As necessary	FWS, AGFC, MDC, KDWPT, ODWC							See Activity 1.2	

NEOSHO MUCKET IMPLEMENTATION SCHEDULE				COST ESTIMATES ($)							Comments
Activity #	**Activity Description**	**Activity Duration**	**Responsible Parties**	**Year 1 – 5**	**Year 6 – 10**	**Year 11 - 15**	**Year 16 - 20**	**Year 21 - 25**	**Year 26 - 30**	**Total Recovery Costs**	
1.24	Assess success of augmentation and reintroduction efforts.	Per PAR Plan	FWS, AGFC, MDC, KDWPT, ODWC, PTIO	50K	50K	50K	50K	50K	50K	300K	
1.25	Translocate Neosho Mucket as necessary to maintain genetic diversity, increase fertilization rates (low population density), and avoid mass die-offs associated with stochastic or anthropogenic-induced events.	As necessary	FWS, AGFC, MDC, KDWPT, ODWC, PTIO							0	Activity will likely occur simultaneously with other activities such as monitoring, propagation, or augmentation.
2.0	Develop and implement a monitoring protocol for the Neosho Mucket.	1 year to develop, continuous thereafter	FWS, AGFC, MDC, KDWPT, ODWC, PTIO	150K	150K	150K	150K	150K	150K	900K	Some salary costs incurred as part of routine agency mussel monitoring programs.
3.1	Determine life span, growth rate, abundance, and availability of host fish, recruitment, and other unknown variables that interact to	2 years	FWS, AGFC, MDC, KDWPT, ODWC, Academia	200K						200K	

NEOSHO MUCKET IMPLEMENTATION SCHEDULE				COST ESTIMATES ($)							Comments
Activity #	**Activity Description**	**Activity Duration**	**Responsible Parties**	**Year 1 – 5**	**Year 6 – 10**	**Year 11 - 15**	**Year 16 - 20**	**Year 21 - 25**	**Year 26 - 30**	**Total Recovery Costs**	
	determine demographic structure and growth rates of populations.										
3.2	Determine genetic variation within and among populations.	3 years	FWS, AGFC, MDC, KDWPT, ODWC, Academia	147K						147K	
3.3	Determine contaminant sensitivity to all life stages	2 years	FWS, AGFC, MDC, KDWPT, ODWC, Academia, USGS	150K						150K	
3.4	Determine sediment deposition rates vs. survivorship of Neosho Mucket.	3 – 4 years	FWS, AGFC, MDC, KDWPT, ODWC, Academia, USGS	150K						150K	
3.5	Determine habitat requirements and limitations to survival for all life stages.	2 years	FWS, AGFC, MDC, KDWPT, ODWC, Academia	150K						150K	

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3.6	Determine interaction between fish host visualizing Neosho Mucket lure and effects on reproduction (i.e. water clarity effects).	1 year	FWS, AGFC, MDC, KDWPT, ODWC, Academia	25K						25K	
3.7	Determine recreational effects to Neosho Mucket and its habitat in the Illinois and Elk Rivers.	2 years	OK Scenic Rivers Commission , Academia	60K						60K	
3.8	Investigate secondary host use by Neosho Mucket and significance of conglutinate release in utilization of hosts	1 year	FWS, AGFC, MDC, KDWPT, ODWC, Academia	50K						50K	
3.9	Determine correlations between prescence/absence and land use and other potential causal effects.	2 years	FWS, AGFC, MDC, KDWPT, ODWC, Academia	150K						150K	
4.1	Restore tail water river reaches.	Continuous	FWS, AGFC, MDC,	Restoration costs will be dependent upon an evaluation of different management scenarios and comparing costs and benefits of addressing needs of multiple						750K	Planning and feasibility

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			KDWPT, ODWC, USACE, FERC	stakeholders and meeting state and federal regulatory requirements.							analysis estimate only.
4.2	Promote and coordinate with existing and future restoration actions in Tri-State Mining area affected waters (e.g., NRDA efforts).	Continuous	FWS, MDC, KDWPT, ODWC, EPA, PTIO	NRDA restoration funds (Spring River basin).							
4.3	Promote ecologically sustainable "green" development and "green spaces" along stream corridors in areas experiencing rapid urbanization	Continuous	FWS, AGFC, MDC, KDWPT, ODWC, NGO	250K	250K					500K	In partnership with city and county government and industry.
4.4	Promote and support a watershed management approach to water quality and quantity.	Continuous	FWS, AGFC, MDC, KDWPT, ODWC, NGO	50K						50K	Supported by Activity 4.3
4.5	Develop coordinated plan to address wastewater	1 year	MODNR, ADEQ, MDC,	100K						100K	Coordinate with municipalities.

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	treatment plant effluents for domestic and industrial wastes.		AGFC, FWS, NGO								
4.6	Promote proper implementation and maintenance of BMPs for reducing sediment loads associated with construction activities.	Continuous	FWS, AGFC, MDC, KDWPT, ODWC	100K	100K					200K	Costs incurred as part of routine agency business.
4.7	Develop and implement standards for water withdrawal and water conservation.	Continuous	FWS, AGFC, MDC, KDWPT, ODWC, USGS	150K	150K	150K				450K	
4.8	Remove non-functional dams (e.g., Lake Francis, low head).	As necessary	FWS, AGFC, MDC, KDWPT, ODWC	Dam removal costs will be dependent upon an evaluation of alternatives, cost-effectiveness, and size of structure.						300K	Planning and feasibility analysis estimate only.
4.9	Adequate industrial, highway, and rail safeguards to minimize potential for catastrophic die-offs.	Continuous	FWS, AGFC, MDC, KDWPT, ODWC, FHWA		150K					150K	

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4.10	Work with state and private partners to promote land and water stewardship awareness within the range of the Neosho Mucket.	Continuous	FWS, AGFC, MDC, KDWPT, ODWC	200K	200K	200K	200K			800K	Salary costs incurred as part of routine agency business.
4.11	Encourage the maintenance and restoration of adequate streamside management zones (SMZs) within the range of Neosho Mucket.	Continuous	FWS, AGFC, MDC, KDWPT, ODWC	We expect existing conservation programs (e.g., Farm Bill, State Private Lands Programs, etc) will be utilized to maintain and restore SMZs. Average costs for planting riparian trees and native grasses/forbs are approximately $500 and $800 per acre, respectively.							Agency salary costs incurred as part of routine agency business.
4.12	Develop and implement tribal programs to promote watershed stewardship on tribal lands. See Recovery Tasks 3.1 and 3.2.	Continuous	FWS, PTIO	200K	200K	200K	200K	200K	200K	1.2M	Based on 1 Tribal Wildlife Grant/5 year period at maximum cost (PTIO)
5.1	Minimize instream effects from activities conducted or permitted by regulatory authorities.	Continuous	FWS, AGFC, MDC, KDWPT, ODWC	20K	20K	20K	20K			80K	Costs incurred as part of routine agency business.

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5.2	Work with states under the Triennial Review Process to ensure water quality standards provide for mussel survival and recovery.	Continuous	FWS, AGFC, MDC, KDWPT, ODWC, EPA	50K	50K	50K	50K	50K	50K	300K	Costs incurred as part of routine agency business.
5.3	Encourage proactive conservation under section 7(a)(1) of the Endangered Species Act.	Continuous	FWS, Federal agencies	100K	100K	100K	100K	100K	100K	600K	
5.4	Develop recommendations to address regulatory deficiencies	Continuous	FWS, AGFC, MDC, KDWPT, ODWC, EPA	50K	5K	5K	5K	5K	5K	75K	Costs incurred as part of routine agency business.
5.5	Encourage cities to adopt (codify) BMPs in their city construction ordinances.	Continuous	FWS, AGFC, MDC, KDWPT, ODWC	200K						200K	Costs incurred as part of routine agency business. Costs focused on Joplin, MO and greater Fayetteville, AR areas.

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6.0	Develop and implement strategies to prevent the spread of competitive, nonindigenous (nonnative) species.	Continuous	FWS, AGFC, MDC, KDWPT, ODWC	100K	100K	100K				300K	Majority of costs incurred as part of routine agency business.
7.0	Periodically review recovery progress and strategy.	Once every 5 years	FWS								Costs absorbed under existing programs

APPENDIX A

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