Final Recovery Plan
for the Diamond Y Invertebrates:

Diamond Tryonia (*Pseudotryonia adamantina*)
Gonzales Tryonia (*Tryonia circumstriata*)
Pecos Amphipod (*Gammarus pecos*)

Southwest Region
U.S. Fish and Wildlife Service
Albuquerque, New Mexico

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Disclaimer

This document presents the U.S. Fish and Wildlife Service (USFWS) plan for the conservation of the three species of the Diamond Y Spring system. The Recovery Plan is the second part of the USFWS's 3-part recovery planning framework and includes the statutorily required elements pursuant to section 4(f) of the Endangered Species Act (ESA). This Recovery Plan is informed by the first part of the framework, a Species Status Assessment (SSA). The SSA report delivers foundational science for informing decisions related to the ESA and includes an analysis of the best available scientific and commercial information regarding a species' life history, biology, and current and future conditions that characterizes the species' viability (i.e., ability to sustain populations in the wild over time) and extinction risk. We are preparing an update to the Recovery Implementation Strategy (RIS), the third part of the framework. The RIS is an easily updateable operational plan that is separate and complementary to the Recovery Plan that details the on-the-ground recovery activities needed to complete the recovery actions contained in the Recovery Plan.

Recovery Plans describe the envisioned recovered state for a listed species (when it may no longer meet the ESA's definitions of a threatened species or endangered species) and include a recovery strategy, recovery criteria, recovery actions, and the estimates of time and cost needed to achieve recovery. Recovery Plans are published by the USFWS and are often prepared with the assistance of recovery teams, contractors, State agencies, and others. Recovery Plans do not necessarily represent the views, official positions, or approval of any individuals or agencies involved in plan formulation, other than the USFWS. They represent the official position of the USFWS only after they have been signed by the Regional Director as approved. Recovery Plans are guiding and planning documents only; identification of an action to be implemented by any public or private party does not create a legal obligation beyond existing legal requirements. Nothing in this plan should be construed as a commitment or requirement that any Federal agency obligate or pay funds in any one fiscal year in excess of appropriations made by Congress for that fiscal year in contravention of the Anti-Deficiency Act, 31 U.S.C. 1341, or any other law or regulation.

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This Recovery Plan was informed by the USFWS Recovery Plan for Four Invertebrate Species of the Pecos River Valley: Noel's amphipod (*Gammarus desperatus*), Koster's springsnail (*Juturnia kosteri*), Roswell springsnail (*Pyrgulopsis roswellensis*), and Pecos assiminea (*Assiminea pecos*) (USFWS 2019, entire). These four invertebrate species inhabit similar desert spring systems in the northern Chihuahuan Desert of the southwestern United States (southeastern New Mexico) and are subject to similar threats. The Pecos assiminea also co-occurs with the Diamond tryonia, Gonzales tryonia, and Pecos amphipod within the Diamond Y Spring system.

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An electronic copy of this Final Recovery Plan may be obtained from any of the species profile pages located within the USFWS's Environmental Conservation Online System (ECOS):

ECOS species profile webpage for Diamond tryonia;

ECOS species profile webpage for Gonzales tryonia; and

ECOS species profile webpage for Pecos amphipod.

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Chapter 1 - Introduction

This Recovery Plan outlines criteria for determining when the listed Diamond Y Invertebrates should be considered for delisting, lists site-specific actions that will be necessary to meet those criteria, and estimates the time and cost to achieve recovery. Additionally, summary information on the species' biology and status are included, along with a brief discussion on factors limiting their populations. The Recovery Plan was informed by a Species Status Assessment (SSA), which provides a more detailed account of the species' status, distribution, biology, and threats (USFWS 2020, entire). Detailed on the ground activities implementing recovery actions will be found in the Recovery Implementation Strategy (RIS) in the future. These supplemental documents are available from any of the species profile pages located within the USFWS Environmental Conservation Online System website (see Acknowledgements section). The RIS and SSA are finalized separately from the Recovery Plan and will be updated on a routine basis.

1.1 Background

The Diamond tryonia (*Pseudotryonia adamantina*), Gonzales tryonia (*Tryonia circumstriata*), and Pecos amphipod (*Gammarus pecos*) (Figures 1 and 2) are aquatic invertebrates that are restricted to a small, isolated desert spring system and ciénega (i.e., desert wetland) in the Chihuahuan Desert of western Texas. Diamond Y Spring system, in Pecos County, contains the largest remaining springs still flowing in that county. Desert springs across the region have experienced significant declines in flow or complete loss of perennial flow due to intensive groundwater pumping for various human uses (Audsley 1956, pp. 7,9, 14-15; Brune 1981, pp. 38, 356-363; Veni 1991, pp. 8-13; Small and Ozuna 1993, pp. 24-29; Cole and Cole 2015, p. 46). The USFWS listed the Diamond tryonia, Gonzales tryonia, and Pecos amphipod, collectively referred to as the Diamond Y Invertebrates, as endangered under the Endangered Species Act of 1973 (ESA), as amended (16 U.S.C. 1531 et seq.), on July 9, 2013 (78 FR 41227).

The Diamond tryonia and Gonzales tryonia are small aquatic snails in the family Cochliopidae. The Diamond tryonia measures 2.9 to 3.6 millimeters (mm) [0.11 to 0.14 inches (in)] in length, and the Gonzales tryonia 3.0 to 3.7 mm (0.12 to 0.15 in) in length (Figure 1) (Taylor 1987, p. 41; Wilke et al. 2001, pp. 8-9, 11-13; Bouchet and Rocroi 2005, pp. 53, 251, 276; Johnson et al. 2013, p. 272; Wilke et al. 2013, p. 722). Given the potential for hydrological connectivity, intermittent or seasonal surface water connections between springs and seeps likely facilitate some gene flow among populations of Diamond and Gonzales tryonia species. However, the absence of genetic data for these species prevents us from assessing their respective population sizes or understanding the reproductive rates needed to sustain a healthy population. Therefore, we consider them as a single population of each species for this evaluation.

Figure 1. Diamond tryonia (left) and Gonzales tryonia (right). Photos courtesy of Pete Diaz, USFWS.

The Pecos amphipod is a member of the *Gammarus pecos* species complex, a group of closely related *Gammarus* species (*G. desperatus*, *G. hyalleloides*, and *G. seideli*) that are restricted to desert spring systems from the Pecos River Basin of southeastern New Mexico and western Texas (Cole 1985, p. 93; Lang et al. 2003, p. 47; Gervasio et al. 2004, p. 521; Seidel et al. 2009, p. 2304-2305, 2308; Cannizzaro et al. 2017, p. 710; Adams et al. 2018, pp. 749, 751). Male amphipods range in size from 12 to 14.9 mm (0.47 to 0.59 in) and females from 9 to 11 mm (0.35 to 0.43 in) (Figure 2). Among three Pecos amphipod occupied sites at Diamond Y Spring system, there is a high degree of genetic similarity (Gervasio et al. 2004, pp. 522, 525-526) and the sites are thus treated as a singular population. There are no current population estimates for the Pecos amphipod, nor do we know what reproductive rates sustain a healthy population.

Figure 2. Pecos amphipod. Photo courtesy of Pete Diaz, USFWS.

The SSA describes the methodology and results of our evaluation of the current condition for Diamond Y Invertebrates, in terms of the resiliency of subpopulations, the redundancy, and representation of the species (USFWS 2020, pp. 65-69). In summary, the Diamond Y Spring system has been impacted by oil and natural gas activities, but the springs, pools, and outflow channels, and surrounding plant community are relatively intact with limited artificial obstructions of free-flowing water (Table 1).

The aquifers supporting the Diamond Y Spring system are under increasing pressure from groundwater pumping in Pecos and Reeves counties. Over the last 19 years, the Rustler Aquifer has experienced historically unprecedented groundwater withdrawals. Similarly, withdrawals from the Edwards-Trinity (Plateau) Aquifer have increased over the last 10 years, reaching volumes comparable to those of the 1980s.

The site's status as a preserve, owned and managed by The Nature Conservancy, has helped maintain the ecological integrity of the spring system and ciénega. However, preserve protections cannot fully mitigate the principal threats to the persistence of the Diamond Y Invertebrates: declining water quantity and degraded water quality, which are stressors operating at much larger spatial scales.

The combination of anthropogenic groundwater withdrawal and climate change-driven variations in precipitation exacerbates groundwater depletion, posing a significant threat to the Diamond Y Invertebrates (Mace and Wade 2008, pp. 657-658; Foster 2009, pp. 391-392, 394-396; Taylor et al. 2012, p. 3; USFWS 2020, pp. 28-38). Although the exact contributions of anthropogenic versus natural sources to water loss are still being studied, it is clear that both play significant roles. While the Groundwater Conservation District is actively researching the causes of aquifer depressurization and working towards better management practices, current desired future conditions do not include mechanisms to regulate groundwater pumping to maintain springflow in local springs, including the Diamond Y Spring system.

Continued research and adaptive management strategies are essential to further understand and mitigate these threats. By addressing both the anthropogenic and natural contributors to groundwater loss, we aim to improve the recovery potential of the Diamond Y Invertebrates.

Table 1. Current condition of habitat elements at Diamond Y Spring system (USFWS 2020, p. 69).

Habitat Element	Diamond Y Spring System Status	Resiliency
Adequate Water Quantity (Groundwater Pumping)	High intensity	Low
Free-flowing Water	Moderately impeded	Moderate
Adequate Water Quality (Contaminant Sources)	Present	Moderate
Intact Ciénega Community	Intact	High
Invasive Competitors and Predators	Abundant	Low

1.2 Management Unit

The Diamond tryonia, Gonzales tryonia, and Pecos amphipod are only known to inhabit the Diamond Y Spring system, a small complex of isolated, desert springs, seeps, and associated ciénegas (desert wetlands), in the Chihuahuan Basin and Playas ecoregion of western Texas (Taylor 1987, pp. 41-42; Veni 1991, pp. 15-17; Boghici 1997, pp. 3-4, 49-53; Griffith et al. 2004; Van Auken et al. 2007, pp. 140-144). The Diamond Y Spring system lies within the tributary drainage of Diamond Y Draw/Leon Creek that drains northeast to the Pecos River (Figure 3). The spring system is located approximately 12 kilometers (km) [8 miles (mi)] north of the City of Fort Stockton in Pecos County, Texas. The Nature Conservancy owns and manages the Diamond Y Spring Preserve, which encompasses the spring and ciénega system (Karges 2003, pp. 143-145).

The range of these species are classified into one Management Unit (Figures 3 and 4), which isn't regulatory. Its boundaries do not pinpoint specific properties needing protection; they're defined solely to aid recovery and management decisions. Management units do not signify distinct population segments but rather denote both the potential habitat extent and biologically distinct areas for targeted recovery actions to mitigate threats. They're essential for conserving genetic diversity, population resiliency, and other features for the long-term sustainability of the three invertebrate species of the Diamond Y Spring system. All management units where a species is present must be recovered to achieve recovery of that species.

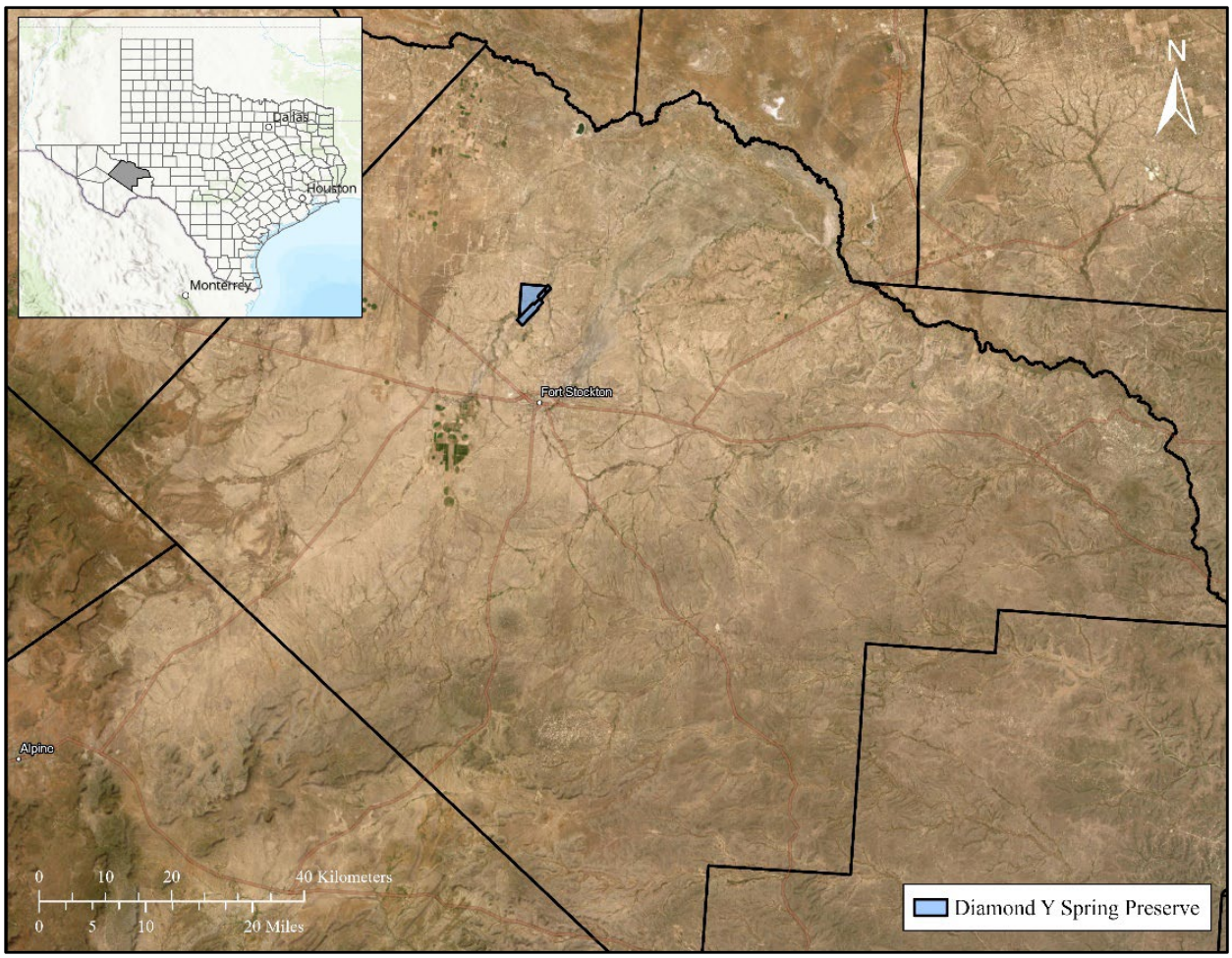

Figure 3. Diamond Y Spring Preserve Management Unit and its relation to the larger landscape in Pecos County, Texas and approximation to the city of Fort Stockton, Texas.

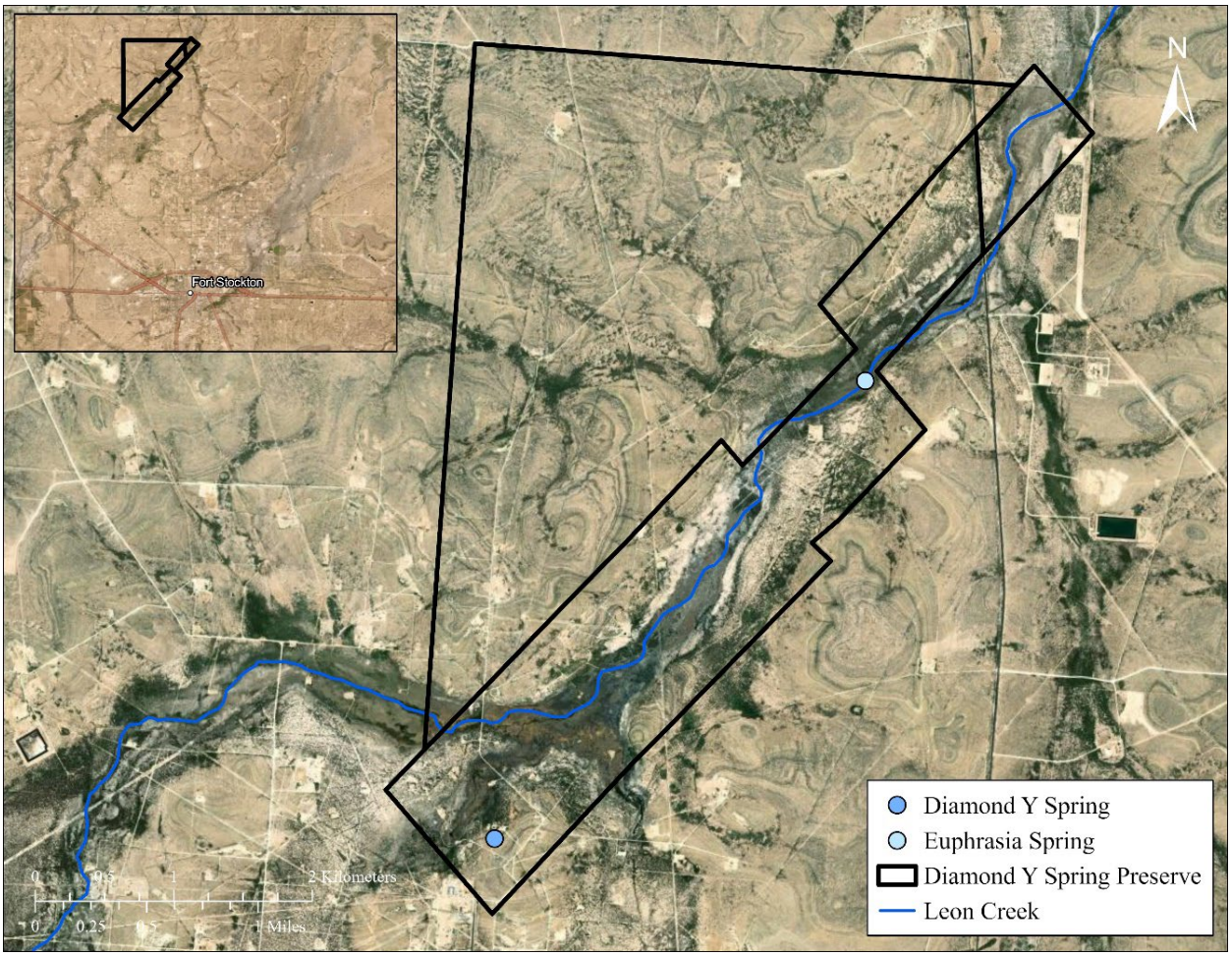

Figure 4. Diamond Y Spring Preserve Management Unit, Pecos County, Texas.

Chapter 2 - Recovery Program

2.1 Recovery Strategy

The recovery strategy provides a concise overview of the envisioned recovered state for the Diamond Y Invertebrates, describes the USFWS chosen approach to achieve it, and includes the rationale for why the approach was chosen.

The overall recovery strategy for the Diamond Y Invertebrates involves preserving, restoring, and managing their aquatic habitat, along with the water resources necessary to support resilient populations and the ecosystems on which they depend. Because of the Diamond Y Spring invertebrates' restricted range, our initial recovery strategy will be to maintain, protect, and monitor the known population within the Management Unit (Figure 4). These actions will be concurrent with initiation and continuation of habitat restoration efforts elsewhere within their historical range. To effectively address the threats of habitat degradation, the strategy emphasizes the importance of collaboration and partnerships. By working cooperatively with municipal, state, and federal agencies, land conservancies, landowners, universities, industry professionals, and other stakeholders, we aim to reduce these threats and close knowledge gaps that are critical for informing recovery efforts. More specifically, the strategy involves:

- Maintaining and managing populations and habitat sites throughout each species' range by ensuring optimal water quality conditions and adequate water quantity, and by protecting and restoring springs, spring-fed habitats, and ciénega communities;
- Addressing threats, such as exposure to catastrophic spills and invasive species, so that the three invertebrate species are capable of enduring stressors;
- Improving our understanding of each species' biology and viability needs and determine the effectiveness of conservation management actions;
- Collaborating with partners and stakeholders to achieve conservation goals by developing and implementing management strategies and plans to benefit the Diamond Y Invertebrates in balance with community water needs; and
- Engaging in community outreach to promote the importance and value of Diamond Y Spring system and its diverse array of wildlife, including sensitive, rare aquatic invertebrates.

2.2 Recovery Criteria

Recovery criteria are statutorily required objective, measurable descriptions of a recovered state for Diamond Y Invertebrates, as described in 4(f)(1)(b)(ii) of the ESA. Recovery criteria describe the conditions of resiliency, redundancy, representation, and threat abatement that indicate when the Diamond Y Invertebrates may no longer meet the ESA definitions of an endangered species or threatened species. Recovery criteria present our best estimate of a species' recovered condition at the time of Recovery Plan development. Changes in available information, technologies, and our understanding of the species over time might mean that the recovered state envisioned by the recovery criteria differs from our assessment in a later status determination.

2.2.1 Downlisting Criteria

The following are objective, measurable downlisting criteria which, when met, may result in a determination that the Diamond tryonia, Gonzales tryonia, and Pecos amphipod be reclassified as threatened species:

Downlisting Criterion 1: A habitat management plan is developed and implemented for all water and lands within the Management Unit for the foreseeable future.

> *Justification*: The three invertebrates are confined to single populations with specific habitat requirements, making it essential to protect both terrestrial and aquatic habitats within the Management Unit (Section 1.2). Due to their limited distribution and specialized needs, they are highly vulnerable to habitat disturbances and environmental changes. Declines in habitat condition, due to reduced groundwater discharges, have been documented since the 1960s, indicating a significant deterioration from the more optimal conditions prior to the 1960s, which were characterized by abundant aquatic species and robust springflow, and serve as important references for historical habitat quality (Kennedy 1977, pp. 93-94; Brune 1981, p. 306; Taylor 1985, pp. 2-5). Research from the 2000s and analysis of current condition further highlights ongoing declines in habitat conditions, reinforcing the urgency for intervention (Echelle et al. 2002, pp. 5-8, 23-25, 51; USFWS 2020, pp. 28, 66-70). The declines observed at the Diamond Y Spring system have occurred to an even greater degree at other springs in western Texas (e.g., Comanche, Leon, Mitchell, Phantom, Santa Isabel, San Pedro, Sandia, and Tunas springs among others;), where groundwater discharge has been dramatically reduced or failed completely, eliminating aquatic habitat (Brune 1981, pp. 357-363, 382-385). The habitat management plan should use these historical references as a guide to improve current conditions and strive to restore aspects of the habitat to its former quality. Without such a plan, these species face an increased risk of population decline or extinction due to a reduction in aquatic habitat availability.

Downlisting Criterion 2: The population of each species within the Management Unit maintains sufficient resiliency, indicated by a stable or increasing average trend in density (average lambda (λ) $\geq$ 0.95), over a 25-year period.

> *Justification*: Invertebrate populations in desert ecosystems are highly variable both temporally and spatially. This criterion focuses on maintaining species presence within the occupied Management Unit despite these fluctuations. Population density will be measured using a rigorously developed, peer-reviewed protocol by the USFWS to ensure accuracy and consistency. A lambda (λ) value between 0.95 and 1.05 signifies a stable population, while a λ greater than 1.05 indicates an increasing population. Trends in density are calculated as the average change in density over time, providing a clear indicator of population health and resilience. Given that droughts significantly influence population dynamics in the Chihuahuan Desert in west Texas, it is critical that the population demonstrates resilience under such conditions. A 25-year timeframe is designed to encompass multiple drought cycles and other stochastic events, thereby ensuring that populations remain stable or increase even during adverse environmental conditions. This timeframe is supported by drought risk evaluations in Rajsekhar et al.

(2015, p. 6,366-6,369) and others (Nielsen-Gammon et al. 2020, pp. 5-6; Gamelin et al. 2022, p. 6) for the region surrounding the Management Unit. The aforementioned drought hazard analysis includes "a combination of several factors like high evapotranspiration rates, low precipitation, and obvious lack of perennial rivers in these regions, contributing toward a higher drought hazard" to understand how the region under consideration will be affected in the event of drought (Rajsekhar et al. 2015, p. 6,368). The criterion duration is adequate to capture natural cycles of wet and dry periods characteristic of the Chihuahuan Desert, allowing for the assessment of long-term population stability and growth, and ensuring that observed trends are not short-term anomalies but reflective of genuine resiliency. Monitoring efforts will further evaluate the relationships between environmental factors between water flow, water quality, substrate characteristics, and population density which inform thresholds for management actions.

Downlisting Criterion 3: A groundwater management plan for all aquifers within the Management Unit is developed and implemented to maintain average springflows over a 25-year period to maintain the resiliency of the Diamond Y Invertebrate populations as defined in Downlisting Criterion 2.

Justification: Long-term water quantity is essential for the survival of the Diamond Y Invertebrates. Current groundwater management practices, such as maintaining aquifer water levels based on desired future conditions, may not sufficiently support springflow, which is critical for these species. Given the complex interplay of various factors affecting groundwater availability, including natural variability in precipitation patterns and the potential exacerbation of drought conditions due to climate change, it is imperative to adopt a forward-looking approach to ensure the continued resilience of the Diamond Y Invertebrate population. Groundwater pumping for agriculture and petroleum extraction has the potential to affect both water quantity and quality, which may in turn impact the Diamond Y Invertebrates, particularly during periods of natural variability in dry-wet cycles and in the context of climate change-induced drought. To address this, it is crucial to map groundwater flowpaths to identify areas where pumping may affect springflow. The most critical period for the invertebrate populations is May through September, when flows in the Diamond Y Spring system often decline or cease temporarily. By collaborating with stakeholders and partners, a management plan can be established to balance economic interests, human water use, and ecological needs. This plan should include measures to ensure that springflows do not fall below critical levels during droughts, preventing negative impacts on invertebrate populations. Achievement of this criterion will be measured through monitoring results and trends outlined in Downlisting Criterion 2, along with hydrologic and detailed habitat data from occupied sites within the Diamond Y Spring system. This approach aims to improve groundwater management, benefiting both the invertebrates and other valued resources in the region and work towards a sustainable future.

Downlisting Criterion 4: Long-term commitments (e.g., conservation agreements) are in place within the Management Unit to maintain water quality standards as determined by Ladd (2010, p. 33). These commitments have been implemented for 25 consecutive years.

Justification: The Diamond Y Invertebrates, confined to a limited geographical area and with limited mobility, are highly vulnerable to environmental disturbances, including those resulting from water contamination events. Given the potential catastrophic impact of such events on the species' populations, it is imperative to establish and maintain long-term commitments ensuring the preservation of water quality within their habitat. These commitments aim to mitigate risks posed by water contamination, thereby safeguarding the species from adverse effects on their health and habitat. Effective habitat management strategies, implemented as part of these commitments, further reduce threats to the Diamond Y Invertebrates by actively addressing potential sources of pollution and habitat degradation. By focusing on the maintenance of specific water quality standards deemed essential for the species' conservation, these commitments contribute to reducing the likelihood of catastrophic events within their habitat and support the long-term viability of Diamond Y Invertebrate populations. Research is ongoing to determine the optimal water quality requirements of the Diamond Y Invertebrates (USFWS 2020, p. 22). Currently, Ladd (2010, p. 33) provides the best available scientific and commercial information for most of the existing springs within the Management Unit. However, the water quality of Karges Spring remains unknown, necessitating further research and evaluation to establish optimal water quality standards. This is particularly important because each spring can differ greatly in water quality within one spring ecosystem (Ladd 2010, pp. 23, 33).

2.2.2 Delisting Criteria

The following delisting criteria, when met collectively, may indicate that Diamond Y Invertebrates no longer meet the ESA definitions of either a threatened species or endangered species, and may be able to be the removed from the Federal Lists of Endangered and Threatened Wildlife and Plants:

Delisting Criterion 1: The population of each species within the Management Unit maintains sufficient resiliency, indicated by an increasing average trend in density (average lambda (λ) $\geq$ 1.05), over a 50-year period.

Justification: This criterion aims to provide a rigorous measure of population health, to not only show that the population is stable but potentially growing, ensuring the species' long-term resiliency and successful recovery. A λ value between 0.95 and 1.05 signifies a stable population, while a λ greater than 1.05 indicates an increasing population. Trends in density are calculated as the average change in density over time, providing a clear indicator of population health and resilience. For delisting purposes, a 50-year period is considered sufficient to monitor the effect of threats such as major drought (Rajsekhar et al. 2015, pp. 6,359, 6,361-6,363, 6,368; Nielsen-Gammon et al. 2020, pp. 5-6; Gamelin et al. 2022, p. 6). The extended duration of an additional 25 years allows for the assessment of the population's ability to persist and thrive despite adverse conditions, including multiple major drought cycles and other environmental stressors characteristic of the Chihuahuan Desert.

Delisting Criterion 2: A groundwater management plan for all aquifers within the Management Unit is developed and implemented to maintain or increase average springflows over a 50-year

period to strengthen the resiliency of the Diamond Y Invertebrate populations as defined in Downlisting Criterion 2.

> *Justification*: By extending the timeframe for the groundwater management plan to a longer horizon, we acknowledge the need for sustained conservation efforts beyond a fixed 25-year period. This adaptive approach allows for ongoing monitoring, evaluation, and adjustment of management strategies in response to changing environmental conditions, thereby maximizing the likelihood of long-term species recovery and eventual delisting. Achievement of this criterion will be measured through monitoring results and trends outlined in Downlisting Criterion 2, along with hydrologic and detailed habitat data from occupied sites within the Diamond Y Spring system. The groundwater management plan will be considered successful for the recovery of the Diamond Y Invertebrates if it effectively prevents long-term declines and cessation of springflow. Additionally, through related conservation efforts, measurable increases in springflows are observed within the 50-year period, resulting in improved habitat conditions within the Diamond Y Spring system in spite of projected changes in precipitation and temperatures (Nielsen-Gammon et al. 2020, pp. 5-6; U.S. Federal Government 2024, unpaginated).

Delisting Criterion 3: Long-term commitments (e.g., conservation agreements) are in place within the Management Unit to maintain water quality standards as determined by Ladd (2010, p. 33). There is a plan for these commitments to be implemented for the foreseeable future.

> *Justification*: The Diamond Y Invertebrates, exclusive to the Diamond Y Spring system, are reliant on optimal water quality conditions for their continued existence. Unlike species with habitat redundancy, the Diamond Y Invertebrates lack alternative viable habitats, rendering them uniquely vulnerable to habitat degradation. Consequently, the assurance of a long-term commitment to maintaining water quality standards is pivotal for their sustained recovery. The ongoing integrity of water quality faces multifaceted threats, including industrial contamination, agricultural runoff, and the pervasive impacts of climate change (USFWS 2020, pp. 26-64). These stressors pose substantial risks to the invertebrates, whose sensitivity to water quality fluctuations makes them particularly susceptible to adverse effects. To address these challenges, robust conservation agreements must have been established within the Management Unit, stipulating sustained adherence to water quality standards delineated by Ladd (2010, p. 33) into the foreseeable future. These agreements are underpinned by the need for systematic monitoring and adaptive management strategies necessary to preempt and mitigate potential threats to water quality. By formalizing these commitments, we affirm our dedication to safeguarding the Diamond Y Invertebrates and their habitat integrity and ensuring resiliency into the future. See Downlisting Criterion 4 for more details on water quality standards and data needs.

2.3 Recovery Actions

Recovery actions are the statutorily required, site-specific management actions needed to achieve recovery criteria, as described in section 4(f)(1)(B)(i) of the ESA. The USFWS assigns recovery action priority numbers (1-3) to rank recovery actions. The assignment of priorities does not imply that some recovery actions are of low importance, but instead implies that lower priority

items may be deferred while higher priority items are being implemented. A Recovery Plan does not commit any entity to implementing the recommended strategies or actions contained within it for a particular species, but rather provides guidance for ameliorating threats (Table 2) and implementing proactive conservation measures. Recovery action priority numbers are based on the following:

> Priority 1 – An action that must be taken to prevent extinction or to prevent the species from declining irreversibly in the foreseeable future.
>
> Priority 2 – An action that must be taken to prevent a substantial decline in species population/habitat quality or some other substantial negative effect short of extinction.
>
> Priority 3 – All other actions necessary to meet the recovery objectives. The assignment of these priorities does not imply that some recovery actions are of low importance, but instead implies that lower priority items may be deferred while higher priority items are being implemented.

Recovery Action 1. Ensure Adequate Water Quantity and Quality within the Management Unit and Supporting Aquifer(s). Priority 1: Key goals of this action include preventing declines in springflows and water quality degradation by determining species-specific water quality needs, identifying and mitigating contamination sources, and implementing conservation water management agreements. Understanding groundwater flow and its impact on springflow within the Management Unit is also crucial. Regular water quality monitoring will help detect and address potential contamination effectively.

Recovery Action 2. Protect and Restore Habitat in Waters and on Lands Within and Connected to the Management Unit. Priority 2: This action focuses on preserving and enhancing the habitat within the Management Unit. Key objectives include protecting springs, spring runs, and upland habitats, maintaining grassland and emergent vegetation, and mitigating the impacts of infrastructure and oil and gas activities within the Management Unit.

Recovery Action 3. Conduct Species Research and Monitoring within the Management Unit and Surrounding Landscape. Priority 3: This action focuses on gaining a comprehensive understanding of the needs and habitat requirements of the Diamond Y Invertebrates, as well as the impacts of various stressors. The goal is to enhance species resilience, representation, and redundancy through targeted research and long-term monitoring. This effort will inform management decisions, assess recovery progress, and establish priorities for future recovery activities, ensuring collaboration with partners for effective implementation.

Recovery Action 4. Establish and Maintain Captive Propagation and Contingency Plans for the Diamond Y Invertebrates. Priority 1: This action aims to safeguard the Diamond Y Invertebrates from extinction due to catastrophic events by developing emergency propagation and contingency plans. Key objectives include understanding species' captivity needs, securing propagation facilities and financial resources, and preparing for potential habitat loss. The plan involves strategies to maintain habitat quality and assessing sites for potential species

translocation, augmentation, or reintroduction to ensure genetic diversity and population stability, enhancing the species' resiliency and representation.

Table 2. Endangered Species Act listing 4(a)(1) factors, threats to the Diamond Y Invertebrates, recovery actions that will address threats, and the recovery criteria to which the actions contribute.

Threat Description	4(a)(1) Factors	Recovery Actions	Downlisting Criteria	Delisting Criteria
Groundwater withdrawal	Factor A: The present or threatened destruction, modification, or curtailment of its habitat or range.	All	2, 3	2
Decreased water quality	Factor A: The present or threatened destruction, modification, or curtailment of its habitat or range	All	All	All
Spring and ciénega modification	Factor A: The present or threatened destruction, modification, or curtailment of its habitat or range	All	1, 2, 4	1, 3
Predation from native and non-native aquatic predators	Factor C: Disease or predation	2, 3, 4	1, 2	1
Groundwater pumping	Factor D: The inadequacy of existing regulatory mechanisms	All	2, 3	2, 3
Competition with non-native snails	Factor E: Other natural or manmade factors affecting its continued existence	2, 3, 4	1, 2	1
Effects of historical reduced aquifer recharge and ongoing climate change	Factor E: Other natural or manmade factors affecting its continued existence	All	All	All

2.4 Time and Cost Estimates

Estimates of time and cost, as defined in section 4(f)(1)(B)(iii) of the ESA, must reflect, to the maximum extent practicable, the total amount of time and costs it will take to achieve the recovery (i.e., delisting) of Diamond Y Invertebrates. The cost estimates provided do not account for possible future inflation and are based on costs of similar actions and typical salary ranges, as well as best professional judgment. Estimated time and costs for the specific activities associated with each Recovery Action are to be specified in the RIS. We intend to update the RIS, in coordination with conservation partners and stakeholders, as frequently as needed by incorporating new pertinent information.

We expect the status of these species to improve in such a way that we may downlist to threatened status in approximately 35 years, following the adoption of this Recovery Plan, and cost approximately $13,890,000. We estimate that the full implementation of the Recovery Actions would improve the status of the Diamond Y Invertebrates so that they could potentially be delisted within 65 years (Table 3) following the adoption of this Recovery Plan and cost approximately $20,940,000 (Table 4) (including $13,890,000 to downlisting plus an additional $7,050,000; Table 6). This time estimate includes up to 15 years to complete the Recovery Actions that are not ongoing until recovery, and 50 years for the Recovery Criteria to be met after the Recovery Actions are implemented.

These timeframes are based on expectation of full funding without delay, implementation of the Recovery Actions and RIS, high degree of success in executed actions, and full cooperation of partners and stakeholders. We note that the Recovery Program may change over time, or the timeframe estimated to implement the Recovery Actions to achieve recovery of the species may take longer than expected. The costs, which encompass only project-specific contract, staff, or operations expenses exceeding base budgets, reflect the estimated monetary outlays of the USFWS and its partners for implementing Recovery Actions. They do not include budgeted amounts that support ongoing agency staff responsibilities, nor do they commit the USFWS or any partners to carry out a particular recovery action or expend the estimated funds. The recovery of the Diamond Y Invertebrates will depend largely on the commitment and the ability of the USFWS and partners to implement the Recovery Actions necessary to achieve the Recovery Criteria.

A Recovery Activity under Recovery Action 1 focuses on preventing water quality degradation. This includes evaluating oil and gas infrastructure within and around the Management Unit to prevent leaks and spills, thereby protecting water quality. This process would involve sampling, feasibility studies, and the plugging of wells. According to the Railroad Commission of Texas (RRC), there are 52 wells within the Management Unit and 53 wells within a 500-meter (1,640-foot) buffer (Forrest et al. 2024, pers. comm.). The USFWS's review of depths for those wells noted a median well depth of 1,034 meters (3,393 feet) for wells with available depth data. None of these are orphaned wells under RRC jurisdiction (Forrest et al. 2024, pers. comm.). The operational status of these wells is unverified, and we cannot accurately predict how many may become orphaned over the next 50 years. Therefore, we refrain from estimating a specific number of potential orphaned wells, and associated costs will be determined as recovery progresses and will be noted within the RIS. Current estimates for plugging a well within the RRC Oil and Gas District 8 is $30.75 per foot (RRC 2024, unpaginated). Thus, a well 1,034 meters (3,393 feet) deep would cost $104,335 to plug.

Table 3. Estimated time necessary to complete Recovery Actions and achieve recovery.

Recovery Action	**Time to Complete Action**	**Implementation Time Needed**	**Total Time**
1. Ensure Adequate Water Quantity and Quality within the Management Unit and Supporting Aquifer(s)	15 years	25 years downlisting; 50 years delisting	65 years
2. Protect and Restore Habitat in Waters and on Lands Within and Connected to the Management Unit	15 years	25 years downlisting; 50 years delisting	65 years
3. Conduct Species Research and Monitoring within the Management Unit and Surrounding Landscape	15 years, varies by species	Continue until 5 years post-delisting	Does not affect recovery timeline; continue until 5 years post-delisting
4. Establish and Maintain Captive Propagation and Contingency Plans for the Diamond Y Invertebrates	5 years	25 years downlisting; continue until 5 years post-delisting	Does not affect recovery timeline; continue until 5 years post-delisting
Total Time to Recovery			**65 years**

Table 4. Estimated costs of Recovery Actions necessary to move towards recovery of the Diamond Y Invertebrates. Costs are based on 60 years to achieve recovery. An asterisk next to a figure indicates an estimate that includes recovery activity costs that are to be determined or unknown. Any cost listed as $0 is covered under existing Federal, State, or partner programs and salaried staff time.

Recovery Actions	**Estimated Cost**
1. Ensure Adequate Water Quantity and Quality within the Management Unit and Supporting Aquifer(s)	$17,757,000*
2. Protect and Restore Habitat in Waters and on Lands Within and Connected to the Management Unit	$814,000
3. Conduct Species Research and Monitoring within the Management Unit and Surrounding Landscape	$2,370,000
4. Establish and Maintain Captive Propagation and Contingency Plans for the Diamond Y Invertebrates	$0
Total estimated cost of recovery actions:	**$20,941,000**

Literature Cited

Adams, N.E., K. Inoue, R.A. Seidel, B.K. Lang, and D.J. Berg. 2018. Isolation drives increased diversification rates in freshwater amphipods. Molecular Phylogenetics and Evolution 127: 746-757.

Audsley, G.L. 1956. Reconnaissance of ground-water development in the Fort Stockton area, Pecos County, Texas. U.S. Department of the Interior Geological Survey. 68 pp.

Boghici, R. 1997. Hydrogeological investigations at Diamond Y Springs and surrounding area, Pecos County, Texas. Master of Arts. The University of Texas at Austin, 113 pp.

Bouchet, P. and J. Rocroi. 2005. Classification and nomenclature of gastropod families. Malacologia 47(1-2): 1-397.

Brune, G. 1981. Springs of Texas. Branch-Smith, Inc., Fort Worth, Texas. 114 pp.

Cannizzaro, A.G., A.D. Walters, and D.J. Berg. 2017. A new species of freshwater *Gammarus* Fabricius, 1775 (Amphipoda: Gammaridae) from a desert spring in Texas, with a key to the species of the genus *Gammarus* from North America. Journal of Crustacean Biology 37(6): 709-722.

Cole, A.T. and C. Cole. 2015. An overview of aridland ciénagas, with proposals for their classification, restoration, and preservation. The New Mexico Botanist, Special Issue 4: 28-56.

Cole, G.A. 1985. Analysis of the *Gammarus-pecos* complex (Crustacea: Amphipoda) in Texas and New Mexico, USA. Journal of the Arizona-Nevada Academy of Science 20(2): 93-104.

Echelle, A.A., A.F. Echelle, and L. Kiner. 2002. Monitoring effects of a renovation project on endangered fish and invertebrates in Diamond Y Draw. Final Report, Endangered Species Program, Texas Parks and Wildlife Department, Austin, Texas. Project No. E-1-13. 66 pp.

Forrest, C., C. Crawford, K. Mays, and S. Larson. 2024, August 13. E-mail: "USFWS-RRC Introductions and Recovery Plan Cost Estimate Assistance."

Foster, J.R. 2009. Do Texas groundwater conservation districts matter? Water Policy 11: 379-399.

Gamelin, B.L., J. Feinstein, J. Wang, J. Bessac, E. Yan, and V.R. Kotamarthi. 2022. Projected U.S. drought extremes through the twenty-first century with vapor pressure deficit. Scientific Reports 12: 8615.

Gervasio, V., D.J. Berg, B.K. Lang, N.L. Allan, and S.I. Guttman. 2004. Genetic diversity in the *Gammarus pecos* species complex: Implications for conservation and regional biogeography in the Chihuahuan Desert. Limnology and Oceanography 49(2): 520-531.

Griffith, G.E., S.A. Bryce, J.M. Omernik, J.A. Comstock, A.C. Rogers, B. Harrison, S.L. Hatch, and D. Bezanson. 2004. Ecoregions of Texas. U.S. Environmental Protection Agency, Corvallis, Oregon.

Johnson, P.D., A.E. Bogan, K.M. Brown, N.M. Burkhead, J.R. Cordeiro, J.T. Garner, P.D. Hatfield, D.A.W. Lepitzki, G.L. Mackie, E. Pip, T.A. Tarpley, J.S. Tiemann, N.V. Whelan, and E.E. Strong. 2013. Conservation status of freshwater gastropods of Canada and the United States. Fisheries 38(6): 247-282.

Karges, J. 2003. Aquatic conservation and The Nature Conservancy in West Texas. In: Garrett, G.P. and N.L. Allan, editors. Aquatic fauna of the northern Chihuahuan Desert. Museum of Texas Tech University Special Publications 46: 151-150.

Kennedy, S.E. 1977. Life history of the Leon Springs pupfish, *Cyprinodon bovinus*. Copeia 1977: 93-103.

Ladd, H.L. 2010. The conservation of native snails within a Chihuahuan Desert spring system. M.S. Thesis. Texas Tech University, Lubbock, Texas. 82 pp.

Lang, B.K., V Gervasio, D.J. Berg, S.I. Guttman, N.L. Allan, M.E. Gordon, and G. Warrick. 2003. Gammarid amphipods of northern Chihuahuan Desert spring systems: An imperiled fauna. Pages 47-57 in Garrett, G.P. and N.L. Allan, editors. Aquatic Fauna of the Northern Chihuahuan Desert. Museum of Texas Tech University, Special Publications Number 46. 160 pp.

Mace, R.E. and S.C. Wade. 2008. In hot water? How climate change may (or may not) affect groundwater resources of Texas. Gulf Coast Association of Geological Societies Transaction 58: 655–668.

Nielsen-Gammon, J., J.L. Banner, B.I. Cook, D.M. Tremaine, C.I. Wong, R.E. Mace, H. Gao, Z. Yang, M.F. Gonzalez, R. Hoffpauir, T. Gooch, and K. Kloesel. 2020. Unprecedented drought challenges for Texas water resources in a changing climate: What do researchers and stakeholders need to know? Earth's Future 8: 20.

Rajsekhar, D. V.P. Singh, and A.K. Mishra. 2015. Integrated drought causality, hazard, and vulnerability assessment for future socioeconomic scenarios: an information theory perspective. Journal of Geophysical Research: Atmospheres 120: 6346-6378.

RRC (Railroad Commission of Texas). 2024. Cost calculation: Plugging cost estimates. Available at: https://www.rrc.texas.gov/oil-and-gas/compliance-enforcement/hb-2259-hb-3134-inactive-well-requirements/cost-calculation/ (Accessed August 15, 2024).

Seidel, R.A., B.K. Lang, and D.J. Berg. 2009. Phylogeographic analysis reveals multiple cryptic species of amphipods (Crustacea: Amphipoda) in Chihuahuan Desert springs. Biological Conservation 142: 2303-2313.

Small, T.A. and G.B. Ozuna. 1993. Ground-water conditions in Pecos County, Texas, 1987. U.S. Geological Survey, Water Resources Investigations Report 92-140. 63 pp.

Taylor, D.W. 1985. Status survey of aquatic molluscs in Diamond Y Draw in Pecos County, Texas. Unpublished report. 27 pp.

Taylor, D.W. 1987. Fresh-water molluscs from New Mexico and vicinity. New Mexico Bureau of Mines and Mineral Resources Bulletin 116: 1-50.

Taylor, R.G., B. Scanlon, P. Döll, M. Rodell, R. van Beek, Y. Wada, L. Longuevergne, M. Leblanc, J.S. Famiglietti, M. Edmunds, L. Konikow, T.R. Green, J. Chen, M. Taniguchi, M.F.P. Bierkens, A. MacDonald, Y. Fan, R.M. Maxwell, Y. Yechieli, J.J. Gurdak, D.M. Allen, M. Shamsudduha, K. Hiscock, P.J.F. Yeh, I. Holman, and H. Treidel. 2012. Ground water and climate change. Nature Climate Change 3: 322-329.

U.S. Federal Government. 2024. U.S. Climate Resilience Toolkit Climate Explorer. Retrieved from: https://crt-climate-explorer.nemac.org (April 19, 2024).

USFWS (U.S. Fish and Wildlife Service). 2019. Recovery plan for four invertebrate species of the Pecos River Valley: Noel's amphipod (*Gammarus desperatus*), Koster's springsnail (*Juturnia kosteri*), Roswell springsnail (*Pyrgulopsis roswellensis*), and Pecos assiminea (*Assiminea pecos*). Southwest Region, Albuquerque, New Mexico. 97 pp.

USFWS (U.S. Fish and Wildlife Service). 2020. Species status assessment for the Diamond Tryonia (*Pseudotryonia adamantina*), Gonzales Tryonia (*Tryonia circumstriata*), and Pecos Amphipod (*Gammarus pecos*). Version 1.0 November 20, 2020. Austin, TX. 106 pp.

USFWS (U.S. Fish and Wildlife Service). 2021. Draft Recovery Implementation Strategy for the Diamond Y Invertebrates: Diamond Tryonia (*Pseudotryonia adamantina*), Gonzales Tryonia (*Tryonia circumstriata*), and Pecos Amphipod (*Gammarus pecos*). July 2021. Southwest Region, Austin Texas, USA. 15 pp.

Van Auken, O.W., M. Grunstra, and S.C. Brown. 2007. Composition and structure of a west Texas salt marsh. Madroño 54: 138-147.

Veni, G. 1991. Delineation and preliminary hydrologic investigation of the Diamond Y Spring, Pecos County, Texas. Final Report, The Nature Conservancy, San Antonio, Texas. 111 pp.

Wilke, T., M. Haase, R. Hershler, H. Liu, B. Misof, and W. Ponder. 2013. Pushing short DNA fragments to the limit: Phylogenetic relationships of 'hydrobioid' gastropods (Caenogastropoda: Rissooidea). Molecular Phylogenetics and Evolution 66: 715-736.

Wilke, T., G.M. Davis, A. Falniowski, F. Giusti, M. Bodon, and M. Szarowska. 2001. Molecular systematics of Hydrobiidae (Mollusca: Gastropoda: Rissooidea): Testing monophyly and phylogenetic relationships. Proceedings of the Academy of Natural Sciences of Philadelphia 151: 1-21.

Appendix 1 – Substantive Peer, Technical, and Public Comments Addressed

We received five requested peer reviews of the Diamond Y Invertebrates Draft Recovery Plan. We requested review from Texas Parks and Wildlife Department, which provided no comment or review, and there were no Tribal interests. We received seven public comments on the Diamond Y Invertebrates Draft Recovery Plan during the comment period which ended January 3, 2022.

During the public comment period for the Draft Recovery Plan, commenters expressed concerns and disagreements. They highlighted the need for more precise and measurable criteria within the plan and sought clarity on the geographic extent of specific recovery actions. Several comments challenged the scientific basis of the draft, particularly regarding historical species presence and groundwater sources, citing insufficient data and conflicting studies. The cost estimates for recovery actions were deemed unrealistic, with comments noting the high market value of water rights and the inadequacy of proposed funding.

Additionally, the adequacy of existing regulatory mechanisms and the complexity of factors affecting groundwater levels and springflow were questioned, including the impact of climate change and natural variations in climate. Commenters provided detailed suggestions for improvement, such as enhancing the hydrogeologic understanding and incorporating findings into future planning. They also emphasized the importance of involving relevant entities in the recovery process to ensure realistic and effective implementation. Substantive comments and how they were addressed are shown in the matrix below.

Comment	Addressed
The Kiner dissertation paper does not support the misleading conclusory statement in the Draft Recovery Plan regarding the decline in the springflow of Diamond Y Spring.	The referenced section has been excluded from the Recovery Plan in accordance with the updated USFWS policy and guidance using the 3-part recovery planning framework. Information of this nature will be reserved for future updates within the SSA, where a section on life history is included. Additionally, it's important to note that the information provided will continue to inform recovery implementation and can be regularly updated in collaboration with partners through the Recovery Implementation Strategy. The best available information indicates that flow of springs within the Diamond Y Spring Preserve have declined over time. While there is an absence of robust monitoring of spring flow, the historical monitoring and observational data that exist suggest flow at Diamond Y Spring has experienced declines since the 1970s, with concomitant reductions in surface water extent (Taylor 1985, pp. 3-5; Echelle et al. 2002, pp. 5-8, 23-25, 51; Kiner 2002, pp. 20-21). Observations at that spring since 2018 have noted protracted (i.e., several months) but temporary cessations in flow, resulting in the drying of outflow channels and pools (USFWS 2020, pp. 30).
The Draft Recovery Plan's assertions that the Diamond tryonia, Gonzales tryonia, and Pecos amphipod historically inhabited Comanche Springs in Pecos County lack sufficient scientific evidence. Given that Comanche Springs has been dry for over six decades and is not viable for species reintroduction or recovery, these claims should be removed. The Plan should be grounded in the best available scientific and commercial data, which the current language in Section 2.2 does not adequately reflect.	Reference to the presence of Diamond tryonia, Gonzales tryonia, and Pecos amphipod at Comanche Springs has been removed from this Recovery Plan. There is historical evidence to indicate that the Diamond tryonia and Gonzales tryonia occurred at Comanche Springs (78 FR 41237). However, we do not know how recently either species inhabited that spring complex given the long-term persistence of empty shell material. No evidence exists regarding the historical occurrence of the Pecos amphipod at Comanche Springs. Given the historical presence of Diamond tryonia and Gonzales tryonia, there is some likelihood that the Pecos amphipod once inhabited Comanche Springs at some point in the past.

Several comments indicated that time and cost estimates for Recovery Actions were unrealistic. Long-term, it would appear that the level of required curtailments is far greater than projected cost estimates in Table 3 of the Draft Recovery Plan, and some costs only cover one year of action. If a Recovery Plan is to be implemented successfully, it should be done so with a reasonable recognition of realistic costs.	USFWS sought partners to better inform the time and cost estimates for this Recovery Action, and they have been updated in the final RP.
The Recovery Action cost estimate is inadequate if it involves acquiring water rights at market value. Additionally, this amount would only suffice to reduce pumping for one year, impacting between 121.25 acre-feet in the oil patch to 2,700 acre-feet for agricultural interests.	USFWS sought partners to better inform the time and cost estimates for this Recovery Action, and they have been updated in the final RP.
Comments included sources of springflow, hydrogeologic setting, and groundwater quality research that has been conducted to better understand Diamond Y Springs and provided cited documentation to USFWS. They continue that they take their management responsibilities seriously by actively improving the hydrogeologic knowledge and tools needed to quantitatively assess potential impacts to springflow. Thus, they are prepared to incorporate those findings into the joint planning process, future rulemakings, amendments to the management plan, and deliberations on permit applications.	The referenced section has been excluded from the Recovery Plan in accordance with the updated USFWS policy and guidance using the 3-part recovery planning framework. Information of this nature will be reserved for future updates within the SSA, where sections on habitat condition in regard to groundwater pumping and groundwater ecosystem dynamics are included. Additionally, it is important to note that the information provided will continue to inform recovery implementation and can be regularly updated in collaboration with partners through the Recovery Implementation Strategy.
Comments discussed the adequacy of existing regulatory mechanisms section of the Draft Recovery Plan regarding groundwater management of the Edwards-Trinity and Rustler aquifers and Texas laws governing groundwater rights, pumping, and regulation.	The referenced section has been excluded from the Recovery Plan in accordance with the updated USFWS policy and guidance using the 3-part recovery planning framework. Information of this nature will be reserved for future updates within the SSA, where a section on groundwater laws and regulations are included. Additionally, it is important to note that the information provided will continue to inform recovery implementation and can be regularly updated in collaboration with partners through the Recovery Implementation Strategy.

Comments referred to the action items under the Recovery Program chapter, including comments on Recovery Actions 1, 2, 3, and 5. These comments included willingness to participate in their implementation and provided information to USFWS regarding research and modeling underway to inform Recovery Action 3.	Our Recovery Activities within the RIS will include the most current and detailed overview of the efforts to aid the recovery of the Diamond Y Invertebrates. This information is crucial for guiding our collaborative recovery initiatives with our partners. When appropriate, we may request our recovery partners to contribute to the RIS updating process.
The Draft Recovery Plan criteria need further clarification and need to be measurable. For example, terms like "adequate water levels" or "stable and perennial" are not measurable. Additionally, the geographic extent of recovery action 2 needs further clarification.	The Recovery Criteria section in the final RP has been updated based on this feedback in order to be more objective and measurable.
There is a lack of quantitative studies on long-term recharge changes to the regional flow system, including potential changes due to historical periods and climate impacts.	We acknowledge the importance of conducting quantitative studies on potential changes in long-term recharge to the regional flow system, including the effects of historical periods and climate change impacts. Currently, such comprehensive studies have not been completed. These studies are incorporated into the draft RIS as Recovery Activity 1-1 under Recovery Action 1 (USFWS 2021, p. 8). The RIS is currently being updated and will be finalized in the future.
Causes to reduction in springflow and groundwater levels are unknown and are complicated. There are other factors to consider aside from the stated "groundwater pumping for economic activities" such as increasing aridity, reduced recharge, changes to regional flow system at Wildhorse Flat-Toyah Basin, and natural tectonic or sedimentation alterations to carbonate system permeability.	The primary threat to the Diamond Y Invertebrates is groundwater loss and depletion resulting from both anthropogenic and natural sources. In the SSA used to inform the listing of these species, we address the potential for increased aridity associated with climate change and variations in precipitation patterns (see Section 8.1 of the SSA). While current data do not allow us to fully distinguish between the impacts of anthropogenic and non-anthropogenic water loss, the graphical representations in Figures 20-21 of the SSA illustrate that natural fluctuations in groundwater levels are exacerbated by direct groundwater withdrawal (i.e., pumping). Revisions have been made to the Recovery Plan where relevant to clarify all contributors to the

	observed water loss at the Diamond Y Spring system.
In Table 2, it was unclear if Listing Factor E included natural changes in climate as a threat (e.g., variation in wet-dry cycles and natural changes during the Pleistocene epoch) in addition to climate change. Flow declines can be lingering effects of past droughts. If drought is more frequent, we may have already observed impacts on Rustler Aquifer. Confined aquifers and role of drought on water levels.	The primary threat to the Diamond Y Invertebrates is groundwater loss and depletion resulting from both anthropogenic and natural sources. In the SSA used to inform the listing of these species, we address the potential for increased aridity associated with climate change and variations in precipitation patterns (see Section 8.1 of the SSA). While current data do not allow us to fully distinguish between the impacts of anthropogenic and non-anthropogenic water loss, the graphical representations in Figures 20-21 of the SSA illustrate that natural fluctuations in groundwater levels are exacerbated by direct groundwater withdrawal (i.e., pumping). Revisions have been made to the Recovery Plan Table 2 to clarify all contributors to the observed water loss at the Diamond Y Spring system.
Comment noting that the Time and Cost Estimate Section does not define entities to participate in recovery.	Estimated time and costs for the specific activities associated with each recovery action are specified in the RIS (USFWS 2024, entire). We intend to update the RIS, in coordination with conservation partners, as frequently as needed by incorporating new pertinent information.